SIMPLIFIED FORMULAS AND TABLES

FOR

FLOORS, JOISTS AND BEAMS; ROOFS, RAFTERS AND PURLINS

BY

N. CLIFFORD RICKER, B.S., M. ARCH., D. ARCH.

Professor of Architecture, University of Illinois; President Illinois Board of Examiners of Architects; Chairman Illinois Commission on Building Laws; Honorary and Active Fellow American Institute of Architects; Fellow American Association for Advancement of Science; Member Western Society of Engineers, Society for Promotion of Engineering Education, American Federation of Arts, Etc.

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PREFACE

Text-books on mechanics of engineering materials seldom make it clear, that both formulas for safety against rupture and for safety against excessive deflection must be applied to any structural problem, relating to members supporting transverse loads. Nor does any city building ordinance known to the author require the use of formulas to prevent excessive deflection. Yet every competent architect and engineer applies them in his practice, knowing that an excessive deflection may occur in long members, entirely safe against rupture, but sufficient to make the structure unsightly and to crack plastering supported by it.

The formulas for rupture and deflection usually given are quite inconvenient in form, because large numbers must be used in computations, requiring the use of seven-place logarithms or tedious arithmetical computations.

By transforming these formulas, changing lengths from inches to feet, loads from pounds to tons, constants for the material from pounds to tons, and bending moments from inch-pounds to foot-tons, simplifying the resulting formulas as much as possible, they may be put into forms far more convenient for practical use, and may then be grouped on a single page for each mode of support and arrangement of the loading. These simplified formulas can be applied with sufficient accuracy by using a good slide rule or a four-place table of logarithms.

Tables have been computed and are here given for the numerical values of $\frac{I}{c}$ and I for rectangular cross-

sections of timbers, and also for the standard cross-sections of cast-iron lintels, which make the determination of their proper sectional dimensions as simple and rapid as in the case of steel shapes.

Tables of four-place logarithms are also added for convenience in computing.

This system of formulas and tables has been used for several years in my classes and practice, saving the larger part of the time and labor usually required, and it is now published to aid architects and engineers in their labors.

To extend the usefulness of the formulas and tables, the proper method is explained for applying them to roofs, in order to determine the safe dimensions of sheathing, rafters, and purlins.

Finally, a series of numerical examples are carefully worked to make the proper use of the work clearly apparent.

N. Clifford Ricker.

Urbana, Ill., March 1, 1913.

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SIMPLIFIED FORMULAS AND TABLES

ERRATA

Page 1, second line from bottom. Read " inch-pounds " instead of " inch-tons."

Page 6, Art. 10. Read " $I = \frac{I}{c} \times 0.248 L \frac{F}{E}$."

Also in fourth and second lines from bottom, read $\frac{F}{E}$ instead of F.

Page 10. Add to the Table of Safe Values:

Hemlock.	0.45	(900).	450	(900,000).

Page 19, ninth line from top. Read

$$" = \frac{30{,}000 \times 360}{8 \times 16{,}000} = 84.38."$$

Ninth line from bottom. Read "$I = 0.047 WL^2 = 0.047 \times 15 \times 30^2 = 628.5$."

Seventh line from bottom. Add: " by the use of simplified formulas."

Page 20, tenth line from bottom. Read "$I = 0.047 WL^2$."

Page 23, eleventh line from bottom. Read " and $5\frac{1}{2}$ feet high."

$M' =$ maximum bending moment in inch-tons acting on the beam.

SIMPLIFIED FORMULAS AND TABLES

1. Ordinary Formulas for Beams.

The formulas for beams supporting transverse loads, commonly given in the text-books, are collected in Table A for comparison and reference. They evidently differ according to the distribution of the load along the beam, and also according to the manner in which its ends are supported or fixed. The cross-section of the beam is here assumed to be constant in dimensions and form throughout its entire length, which is always the case for wooden timbers and steel shapes.

2. Notation Employed in the Ordinary Formulas. Table A.

Let P = total load in pounds supported by the beam.

l = clear span in inches of the beam.

S = maximum safe fibre stress in pounds per square inch acting at a cross-section.

E' = modulus of elasticity in pounds per square inch for its material.

E' = tensile stress which would theoretically stretch a bar 1 inch square to twice its original length.

$\frac{I}{c}$ = section modulus of cross-section of beam.

I = section moment of inertia of the same.

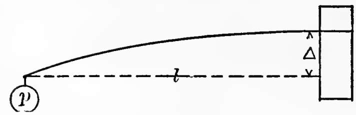
c = maximum distance in inches from horizontal gravity axis of cross-section to its most distant fibre.

Δ = maximum deflection of beam in inches, usually limited to $\frac{l}{360}$.

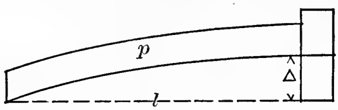
M' = maximum bending moment in inch-tons acting on the beam.

3. Table A. Formulas for Beams.

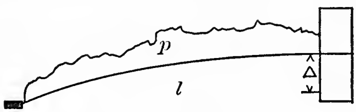
CASE

1.


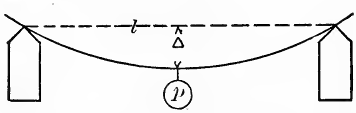
$$Pl = S\frac{I}{c}. \quad \Delta = \frac{Pl^3}{3E'I}.$$

2.


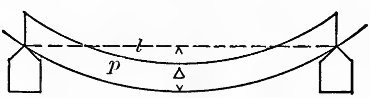
$$\frac{Pl}{2} = S\frac{I}{c}. \quad \Delta = \frac{Pl^3}{8E'I}.$$

3.


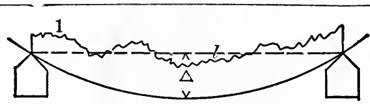
$$M' = S\frac{I}{c}. \quad \Delta = \frac{Pl^3}{(3 \text{ to } 8)E'I}.$$

4.


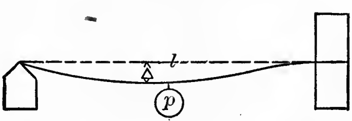
$$\frac{Pl}{4} = S\frac{I}{c}. \quad \Delta = \frac{Pl^3}{48E'I}.$$

5.


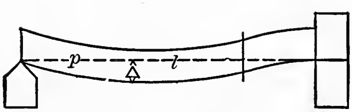
$$\frac{Pl}{8} = S\frac{I}{c}. \quad \Delta = \frac{5Pl^3}{384E'I}.$$

6.


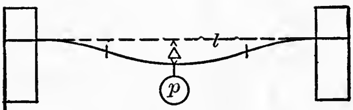
$$M' = S\frac{I}{c}. \quad \Delta = \frac{Pl^3}{(48 \text{ to } 77)E'I}.$$

7.


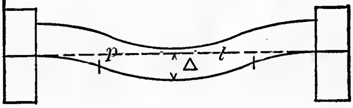
$$\frac{3Pl}{16} = S\frac{I}{c}. \quad \Delta = \frac{7Pl^3}{768E'I}.$$

8.


$$\frac{Pl}{8} = S\frac{I}{c}. \quad \Delta = \frac{Pl^3}{185E'I}.$$

9.


$$\frac{Pl}{8} = S\frac{I}{c}. \quad \Delta = \frac{Pl^3}{192E'I}.$$

10


$$\frac{Pl}{12} = S\frac{I}{c}. \quad \Delta = \frac{Pl^3}{384E'I}.$$

4. Inconvenient Use of Ordinary Formulas.

As an illustration, take the following practical example. A steel beam is to be composed of two steel I-beams, is 30 ft. long and must safely support a uniformly distributed load of 20,000 lbs. Its most economical cross-section and actual maximum deflection are to be determined. For rolled steel shapes, $S=16{,}000$ lbs., $E'=29{,}000{,}000$, and $l=360$ ins.

By formulas for Case 5, Table A:

$$\frac{P\,l}{8}=S\,\frac{I}{c}; \text{ transposing; } \frac{I}{c}=\frac{P\,l}{8\,S}=\frac{20000\times360}{8\times16000}=56.12.$$

$$\Delta=\frac{5\,P\,l^3}{384\,E'\,I}; \text{ transposing;}$$

$$I=\frac{75\,P\,l^2}{16\,E'}=\frac{75\times20000\times129600}{16\times29000000}=418.97.$$

Since two I-beams are to be used, for each, $\frac{I}{c}=28.06$ and $I=209.69$.

By "Cambria": two 12 in., 31.5 lb. I-beams will suffice for both values.

For the selected section, $I=2\times215.8=431.6$ for both beams.

$$\text{Then } \Delta=\frac{5\,P\,l^3}{384\,E'\,I}=\frac{5\times20000\times46656000}{384\times29000000\times431.6}=0.971 \text{ inch.}$$

Since this maximum deflection should not exceed $\frac{l}{360}=1$ in., this compound beam may be safely employed.

Even with the use of logarithms in solving this problem, it is evident that the use of the ordinary formulas requires considerable time and a large number of figures, with possible errors in the computations, and that they are

not adapted for use on the slide rule. Also, that if these formulas can be materially simplified, much time and labor can be saved, and it may become entirely possible to make the necessary calculations with four-place logarithms or a good slide rule, obtaining results sufficiently accurate for any practical purpose.

5. Method for Simplifying the Ordinary Formulas.

The following changes are made in the ordinary formulas in Table A:

a. Change load on beam from pounds to tons.

b. Change numerical values of S and E' in pounds to F and E in tons.

c. Change length of beam from l in inches to L in feet.

d. Change bending moments from inch-pounds to foot-tons.

Other values remain as before.

6. Notation Employed in the Simplified Formulas.

Let W = total load on beam in tons.
w = total load in pounds per square foot of a floor.
L = length of beam in feet, or distance between centres of beams.
e = distance in inches between centres of floor joists.
t = thickness in inches of the flooring.
F = maximum safe fibre stress in tons per square inch.
E = modulus of elasticity in tons.
M = maximum bending moment in foot-tons.
Δ = maximum deflection of beam in inches; should not exceed $\frac{L}{30}$.

7. Method of Simplification.

In simplifying or transforming a formula, care must always be taken to preserve the numerical value of each side of the equation representing the formula.

As an example of the application of the method, take the ordinary formulas given for Case 5 in Table A.

Substitute $2000\,W$ for P; $12\,L$ for l; $2000\,F$ for S; $2000\,E$ for E'; and $\frac{L}{30}$ for Δ. Then reduce the equation to its simplest form and transpose to obtain the forms most convenient for use.

$$\frac{P\,l}{8} = S\frac{I}{c} = \frac{2000\,W \times 12\,L}{8} = 2000\,F\frac{I}{c} = 1.5\,WL = F\frac{I}{c}.$$

$$\Delta = \frac{5\,P\,l^3}{384\,E'\,I} = \frac{5 \times 2000\,W \times 1728\,L^3}{384 \times 2000\,E\,I} = \frac{L}{30} = \frac{22.5\,WL^3}{E\,I}.$$

8. General Simplified Formulas for Case 5.

The formulas just obtained may be put into forms more convenient for use.

$$1.5\,WL = F\frac{I}{c}. \qquad \frac{L}{30} = \frac{22.5W\,L^3}{E\,I}.$$

$$\frac{I}{c} = \frac{1.5\,WL}{F} = \text{section modulus.} \qquad I = \frac{675\,WL^2}{E} = \text{section moment of inertia.}$$

$$W = \frac{I}{c} \times \frac{F}{1.5\,L} = \text{safe load.} \qquad W = \frac{E\,I}{675\,L^2} = \text{safe load.}$$

$$L = \frac{I}{c} \times \frac{F}{1.5\,W} = \text{safe length.} \qquad L = \sqrt{\frac{E\,I}{675\,W}} = \text{safe length.}$$

9. Special Formulas for any Material.

For example, take the general formulas just found, adapt them to steel by substituting the numerical values for F and E and reduce to simplest form.

$$\frac{I}{c} = \frac{1.5\,WL}{8} = 0.187\,WL. \qquad I = \frac{675\,WL^2}{14500} = 0.047\,WL^2.$$

$$W = \frac{I}{c} \times \frac{8}{1.5\,L} = \frac{I}{c} \times \frac{5.333}{L}. \quad W = \frac{14500\,I}{675 L^2} = 21.5\frac{I}{L^2}.$$

$$L = \frac{I}{c} \times \frac{8}{1.5\,W} = \frac{I}{c} \times \frac{5.333}{W}. \quad L = \sqrt{\frac{14500\,I}{675\,W}} = 4.64\sqrt{\frac{I}{W}}.$$

10. Formula for Directly Computing the Numerical Value of I from that of $\frac{I}{c}$.

Evidently for a beam of a given length, load, and material, the numerical values in the preceding general formulas for W are equal, may be equated and simplified for I.

Then

$$\frac{I}{c} \times \frac{F}{1.5\,L} = \frac{EI}{675\,L}, \text{ from which is found } I = \frac{I}{c} \times 450\,L\,F.$$

Therefore in Case 5, after obtaining the numerical value of $\frac{I}{c}$, it may save time to multiply this value by $450\,L\,F$ instead of using the formula given in Art. 9 for I. This formula may also be simplified by inserting the value of F and reducing, making it very convenient for the slide rule.

11. Formula for Maximum Safe Fibre Stress and Deflection.

The preceding formulas for safety against rupture and excessive deflection are entirely independent of each other. Therefore, if a beam of any given material and uniform cross-section be assumed, its safe load W be computed by both formulas for successive lengths L, and the values of W be plotted, two curves will be obtained and intersect at a common point at which the numerical values of W and L will be respectively equal, as illustrated in Fig. 11. Hence for the intersection, we may equate the

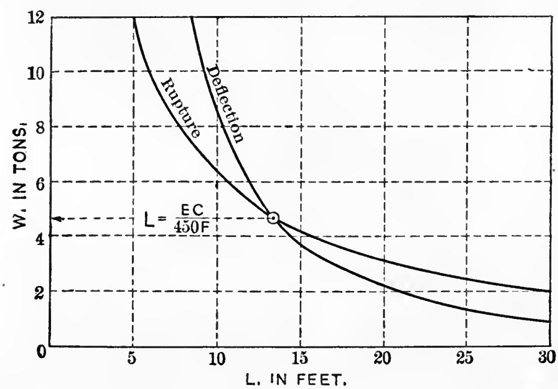


FIG. 11.

values of W in the two equations, obtaining in Case 5, $L = \dfrac{E\,c}{450\,F}$. For F and E may then be substituted the numerical values for any material, thus producing a very simple formula, so that L can be found by it directly.

For lengths less than L by this formula, the formula for safety against rupture gives safest results; for those greater than L, the formula against excessive deflection is safest. Hence if this value of L be known for any material, it is only necessary to apply one formula below it and the other above it.

12. Actual Maximum Deflection.

This formula gives the actual maximum deflection of the beam in inches.

$$\Delta = \frac{5\,Pl^3}{384\,E'I} = \frac{5 \times 2000\,W \times 1728\,L^3}{384 \times 2000\,E\,I} = \frac{22.5\,WL^3}{E\,I}.$$

13. General Formulas for Floor Joists. Case 5 a.

Let e = distance in inches between centres of joists.
w = total live and dead loads in pounds per square foot of floor.

Then $$L = \frac{e}{12} \times \frac{w}{2000} = W = \frac{w\,L\,e}{24000}.$$

Substituting this value for W in the general formulas for W and simplifying,

$$\frac{I}{c} = \frac{1.5\,WL}{F} = \frac{1.5\,w\,L^2e}{24000\,F} = \frac{w\,L^2e}{16000\,F}.$$

$$I = \frac{675\,WL^2}{E} = \frac{675\,w\,L^3e}{24000\,E} = \frac{w\,L^3e}{35.56\,E}.$$

Then by transposition:

$$\frac{I}{c} = \frac{w\,L^2e}{16000\,F}. \qquad I = \frac{w\,L^3e}{35.56\,E}.$$

$$w = \frac{I}{c} \times \frac{16000\,F}{L^2e}. \qquad w = \frac{35.56\,E\,I}{L^3e}.$$

$$e = \frac{I}{c} \times \frac{16000\,F}{w\,L^2}. \qquad e = \frac{35.56\,E\,I}{w\,L^3}.$$

$$L = \sqrt{\frac{I}{c} \times \frac{16000\,F}{w\,e}}. \qquad L = \sqrt[3]{\frac{35.56\,E\,I}{w\,e}}.$$

By inserting the values of F and E, these general formulas are changed into simpler formulas for any particular material.

The formulas for directly computing I from $\frac{I}{c}$ and for L for maximum safe fibre stress and deflection are unchanged from those found for Case 5.

For actual deflection of a joist, substituting value of W and simplifying:

$$\Delta = \frac{22.5\, w\, L^4 e}{24000\, E\, I} = \frac{w\, L^4 e}{1067\, E\, I}.$$

14. General Formulas for Flooring. Case 5 b.

Let t = thickness in inches of the flooring.

Take $e = 12$ ins., assuming a strip of floor 1 ft. wide. Then for the rectangular section of a floor board:

$$\frac{I}{c} = \frac{b\, t^2}{6} = \frac{12\, t^2}{6} = 2t^2. \qquad I = \frac{b\, t^3}{12} = \frac{12\, t^3}{12} = t^3.$$

Substituting 12 for e, $2\, t^2$ for $\frac{I}{c}$, and t^3 for I in equations for floor joists and simplifying:

$$2\, t^2 = \frac{12\, w\, L^2}{16000\, F}. \qquad t^3 = \frac{12\, w\, L^3}{35.56\, E}.$$

$$t = \sqrt{\frac{w\, L^2}{2667\, F}}. \qquad t = \sqrt{\frac{w\, L^3}{2.96\, E}}.$$

$$w = \frac{2667\, F\, t^2}{L^2}. \qquad w = \frac{2.96\, E\, t^3}{L^3}.$$

$$L = \sqrt{\frac{2667\, F\, t^2}{w}}. \qquad L = \sqrt[3]{\frac{2.96\, E\, t^3}{w}}.$$

These formulas may be further simplified by inserting the values of F and E for the particular material.

The general formula for maximum safe fibre stress and deflection is obtained by equating the values just found for w and simplifying.

$$L = \frac{E\,t}{933\,F}.$$

The general formula for actual deflection is obtained by substituting t^3 for I in the formula for actual deflection of a joist and reducing.

$$\Delta = \frac{w\,L^4 e}{1067\,E\,t^3}.$$

15. General and Special Formulas for Cases 1 to 10.

These are derived from the ordinary formulas given in Table A by the method just explained and applied to those of Cases 5, 5 *a* and 5 *b*.

16. Numerical Safe Values recommended for F and E.

Material.	*F.*	Lbs.	*E.*	Lbs.
Cedar	0.45	(900)	450	(900,000)
Cypress	0.50	(1,000)	550	(1,100,000)
Fir, Washington	0.70	(1,400)	700	(1,400,000)
Gum	0.55	(1,100)	650	(1,300,000)
Iron, cast. Tension	1.50	(3,000)	8,000	(16,000,000)
Iron, wrought	6.00	(12,000)	14,000	(28,000,000)
Maple, sugar	0.75	(1,500)	800	(1,600,000)
Oak, white	0.65	(1,300)	750	(1,500,000)
Pine, longleaf	0.70	(1,400)	850	(1,700,000)
Pine, Norway	0.50	(1,000)	600	(1,200,000)
Pine, pitch	0.55	(1,100)	600	(1,200,000)
Pine, shortleaf	0.55	(1,100)	600	(1,200,000)
Pine, white	0.45	(900)	500	(1,000,000)
Poplar, yellow	0.45	(900)	500	(1,000,000)
Redwood	0.40	(800)	350	(700,000)
Spruce	0.55	(1,100)	650	(1,300,000)
Steel shapes	8.00	(16,000)	14,500	(29,000,000)

These are safe average values, based on the results of experiments and the average requirements of the building ordinances of the principal cities in the United States. The corresponding safe values for any other materials, or those prescribed by any building ordinance, may easily be inserted in the general formulas for the particular case, then simplified to obtain the working formulas.

17. Special Formulas for the Commonly Used Materials.

From the simplified general formulas for Cases 1 to 10, by substituting the proper values of F and E taken from Art. 16 and simplifying, are derived the special formulas here given for steel, cast iron, Washington fir, hemlock, white oak, longleaf, shortleaf, and white pine, and for spruce. These materials have been selected because they are more commonly employed in the Middle and Eastern States. These special formulas are then most rapidly applied by using four-place logarithms or a good slide rule.

18. Tables of Properties of Rectangular Sections.

Tables 19 and 20 are to be used in determining the dimensions of timbers corresponding to the values of $\frac{I}{c}$ and I obtained by the formulas. The upper horizontal line of figures represents the horizontal breadth of the section, and the left-hand vertical line contains the vertical depth. The numerical values of $\frac{I}{c}$ in Table 19 are computed by the usual formula,

$$\frac{I}{c}=\frac{b\,d^2}{6}.$$

Those of I in Table 20 are obtained by the formula,

$$I=\frac{b\,d^3}{12}.$$

19. Tables of Properties of Sections of Cast-iron Lintels.

These tables include the stock sections and sectional dimensions of lintels usually furnished by the large foundries. It is not economical to design other sections, excepting when a considerable number are to be cast from the new pattern required. Lintels are now generally composed of pairs of steel I-beams. Cast-iron lintels should only be used in Case 4, 5, or 6, since their design becomes too complex in the other cases.

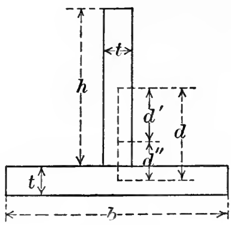


FIG. 12.

Fig. 12 is the section of an inverted T-section, also applicable to an L-section; Fig. 13 is that of a box lintel; and Fig. 14 is a box lintel with

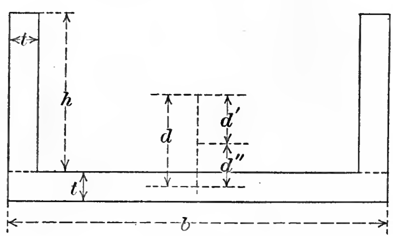


FIG. 13.

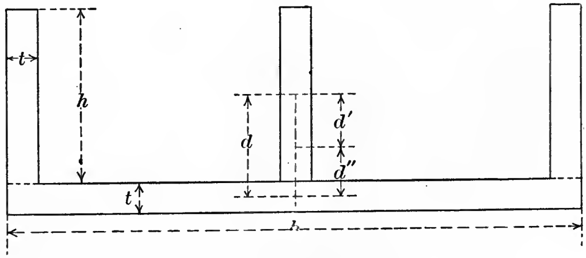


FIG. 16.

three webs. Flanges and webs have equal thickness of metal, and they are to be connected at proper distances by cross webs to prevent crippling.

The formulas employed in the computations were obtained as follows:

Let t = uniform thickness of metal in inches.
h = height of webs from flange in inches.
b = breadth of flange in inches.
A = total sectional area of lintel in square inches.
A' = total sectional area of webs in square inches.
A'' = total sectional area of flange in square inches.
d = vertical distance in inches between horizontal gravity axes of webs and flange.
$d_{,}$ = vertical distance in inches between gravity axis of webs and neutral axis of entire section.
$d_{,,}$ = vertical distance in inches between gravity axis of flange and neutral axis of entire section.
c = distance in inches between bottom of flange and neutral axis of section.
I = moment of inertia of the entire section about its neutral axis.
I' = moment of inertia of all webs about their horizontal gravity axis.
I'' = moment of inertia of flange about its horizontal gravity axis.
$\frac{I}{c}$ = section modulus of entire section about its neutral axis on tension side.

Then $d=\frac{h+t}{2}$ = half depth of lintel in inches.

Also for location of the neutral axis of the entire section.

$$A : A' : d : d_{,,}; \quad \text{hence } d_{,,}=\frac{A'd}{A}.$$

By the usual formula for I about any axis parallel to its gravity axis:

$I=I'+A'd_{,}^2+I''+A''d_{,,}^2$ = moment of inertia of entire section.

Also $c=d_{,,}+\frac{t}{2}$, and $\frac{I}{c}$ = section modulus.

20. Tables of Logarithms.

In order to make this work as convenient as possible, two tables of four-place logarithms have been added in Tables 24 and 25, one extending from 0 to 999, the other from 1000 to 1999. These will be found sufficient for solving problems relating to beams, joists, and flooring. Or a good slide rule may be employed, saving some time and the labor of writing down the logarithms, but with more liability to error in locating the decimal point.

21. Application of Formulas and Tables to Roofs.

These simplified formulas may be applied to roofs as well as to floors, in the following manner.

Loads on roofs are composed of four different kinds:

1. Permanent loads in pounds per square foot of inclined surface, acting vertically, and consisting of weight of covering, sheathing, rafters, and purlins.

2. Snow load in pounds per horizontal square foot, acting vertically, its magnitude varying from 0 to 35 lbs., according to latitude.

3. Wind load or pressure in pounds per square foot of inclined surface, acting at right angles to the latter, its magnitude varying from 0 to 50 lbs., according to exposure and inclination of the roof.

4. Accidental loads, for example, 25 lbs. per square foot of a flat roof for weight of snow, firemen, etc. Acts vertically.

The weight of the trusses supporting the roof is not included here.

22. Notation and Formulas Employed for Loads on Roofs.

Let p = permanent load in pounds per square foot of inclined surface.

s = snow load in pounds per square foot of horizontal surface.

w = wind load in pounds per square foot of inclined surface.

i° = angle of inclination of surface from horizontal.

Then $s \cos i$ = snow load in pounds per square foot of inclined surface.

For a flat roof, $\cos i = 1$, $w = 0$; the roof is then treated like a floor.

$p \cos i^\circ$ = normal component of permanent load p.
$p \sin i^\circ$ = parallel component of permanent load p.
$s \cos^2 i^\circ$ = normal component of snow load $s \cos i$.
$s \sin i^\circ \cos i^\circ$ = parallel component of snow load $s \cos i$.
w = normal component of wind load w.
0 = parallel component of wind load w.

Since the maximum snow load and wind load can scarcely occur simultaneously on the roof surface, we may have either one of two cases.

a. Permanent and snow loads form the maximum loading.

$\cos i\,(p + s \cos i)$ = normal component of p and s loads.
$\sin i(p + s \cos i)$ = parallel component of p and s loads.

b. Permanent and wind loads form the maximum loading.

$p \cos i + w$ = normal component of p and w loads.
$p \sin i + 0$ = parallel component of p and w loads.

Either pair, *a* or *b*, of formulas are to be employed, which corresponds to the mode of loading, that produces the maximum stresses in the roof.

23. Sheathing.

Here p = weight of covering + weight of sheathing per inclined square foot.

For an inclined roof the parallel component of this loading may usually be neglected, since it is safely resisted by the edgewise strength of the sheathing. Take the maximum normal component, substitute this for w in the formulas of Case 5 b to determine L = maximum safe distance in feet between centres of the supporting rafters.

24. Rafters.

Here p = weight of covering + weight of sheathing + average weight of rafters per inclined square foot.

The maximum normal component acts transversely and its value is substituted for w in the formulas of Case 5 a to determine $\frac{I}{c}$ and I; the dimensions of cross-section of rafters are then found. By applying the formula for Δ, Case 5 a, the maximum deflection Δ of the rafter is found.

The parallel component of the loading acts lengthwise the rafter producing compression. The magnitude of this compression at mid-length of rafter $= \dfrac{e\,L \times \text{par. component}}{48000}$ in tons.

Let u = uniform compression in tons per square inch at this section of rafter.

d = depth of rafter in inches, for rectangular, I or channel section.

Then $u\left(1+\dfrac{6\Delta}{d}\right)$ = maximum compression in top fibres in tons per square inch.

This is then to be deducted from the value of F employed for the material in the formulas of Case 5 a;

substitute the remainder for F in the general formula and compute anew the proper values of $\frac{I}{c}$, I and dimensions of rafter. In all roofs of ordinary inclination, this parallel component may be neglected.

25. Purlins.

Here p = weights of covering + sheathing + average for rafters + average for purlins per inclined square foot.

Purlins may be set in either of three ways:

a. With middle or major axial plane containing resultant of all loads on purlin. But these loads are liable to variation, and this resultant then varies in magnitude and direction.

b. Major axial plane at right angles (normal) to roof surface.

Let W = total load in tons on purlin uniformly distributed.
W' = normal component of loads on purlin.
W'' = parallel component of loads on purlin.

c. Major axial plan vertical and making angle $j°$ with resultant of maximum simultaneous loads on purlin.

$W' = W \cos j°$ = vertical component of loads on purlin.
$W'' = W \sin j°$ = horizontal component of loads on purlin.

After obtaining the component W', which acts in the major axial plane of the purlin, and W'', that acts at right angles to the former, the formulas of Case 5 are applied to obtain $\frac{I}{c}$ and of I for each component. A section is then selected that has the required values of $\frac{I}{c}$ and I in the two directions.

1. For a timber purlin, the required sectional dimensions may be found by Tables 19 and 20, selecting a section possessing the required values of $\frac{I}{c}$ and I in the respective directions.

2. For a steel purlin, which may be composed of two I-beams latticed together and spaced apart sufficiently to have the required stiffness sidewise. Or, more commonly, a single I-beam is used with the required values of $\frac{I}{c}$ and I for the component W'. This beam is then subdivided in equal spans by one or more suspension rods extending up to the ridge of the roof, so that its stiffness sidewise is sufficient for each short span.

But since the neutral axis of the purlin is not usually at right angles to its major axial plane, the angles of this section will not be equidistant from this neutral axis, and those more distant will be more stressed, than if the neutral axis were parallel to the top of the purlin.

Therefore, the following formula is then to be applied to determine the maximum fibre stress found in these more distant angles, and whether it exceeds the safe limit for the material used.

Let b = parallel breadth of the purlin in inches.
d = normal depth of purlin in inches.
I_y = moment of inertia about parallel minor axis of section.
I_x = moment of inertia about normal major axis of section.

Then $0.75\,L\left(\frac{W'd}{I_y}+\frac{W''b}{I_x}\right)$ = maximum fibre stress in tons per square inch.

If this exceeds the safe value for the material, a larger section must be taken, until a sufficient one is obtained. This formula must be applied to purlins of wood or steel excepting when W' coincides with the major axial plane of the cross-section.

26. Application of Formulas to Problems.

Some problems will illustrate the practical use of the formulas and tables.

PROBLEM 1. A steel girder is 30 ft. long and must safely support a uniform load of 15 tons. To be composed of two I-beams with separators and bolts.

a. By ordinary formulas, Case 5, Table A.

For safety against rupture: $\frac{P\,l}{8} = \frac{S\,I}{c}$.

Transposing: $\frac{I}{c} = \frac{P\,l}{8\,S} = \frac{30000+360}{8\times16000} = 84.38.$

For safety against excessive deflection: $\Delta = \frac{5\,P\,l^3}{384\,E\,I}$.

Transposing:

$$I = \frac{5\times360\,P\,l^2}{384\,E} = \frac{5\times360\times30000\times129600}{384\times29000000} = 628.45.$$

b. By simplified formulas, Case 5, Table 7.

For safety against rupture:

$$\frac{I}{c} = 0.187\,W\,L = 0.187\times15\times30 = 84.4.$$

For safety against deflection:

$$I = 1.192\,W\,L^2 = 1.192\times15\times30^2 = 628.5$$

By Cambria, 2, 15 in., 42· lb. I-beams are required. Comparison shows a decided economy in time and labor in computations.

PROBLEM 2. Beam cantilever with uniform load, Case 2, Table 2. Free length 10 ft., and supporting a load of 0.5 ton per foot. Washington fir.

$$\frac{I}{c} = 8.58\,W\,L = 8.58\times5\times10 = 429.$$

$$I = 9.26\,W\,L^2 = 9.26\times5\times10^2 = 4630.$$

By Table 19 for $\frac{I}{c}$: 8×18, 10×16, 12×16, 14×14 ins.

By Table 20 for I: 8×20, 10×18, 12×18, 14×16 ins. Therefore the beam may be made 10×18 or 14×16, as most convenient.

PROBLEM 3. Beam supported at ends with load at middle. Case 4, Table 6. Beam of shortleaf pine 16 ft. clear span, which must safely support a load of 3 tons at middle of span.

$$\frac{I}{c} = 5.45\ W\ L = 5.45 \times 3 \times 16 = 262.$$

$$I = 1.802\ W\ L^2 = 1.802 \times 3 \times 16^2 = 1384.$$

By Table 19 for $\frac{I}{c}$: 4×20, 6×18, 8×14, 10×14, 12×12.

By Table 20 for I: 4×18, 6×16, 8×14, 10×12, 12×12. Most economical to make the section 8×14 ins.

PROBLEM 4. Steel floor beam supporting hollow tile floor, Case 5, Table 7. Beam 16 ft. long and set 4 ft. on centres. Must safely support a total live and dead load of 146 lbs. per square foot of floor.

$$\text{Here } W = \frac{146}{2000} \times 4 \times 16 = 4.673 \text{ tons.}$$

$$\frac{I}{c} = 0.187\ W\ L = 0.187 \times 4.673 \times 16 = 13.98.$$

$$I = 0.046\ W\ L^2 = 0.047 \times 4.673 \times 16^2 = 56.22.$$

By Cambria: 1, 8 in., 18 lb. I-beam just suffices.

PROBLEM 5. Joists supporting floor and ceiling, Case 5 a, Table 8. Shortleaf pine joists 18 ft. long and set 16 ins. on centres must safely support a total live and dead load of 65 lbs. per square foot.

$$\frac{I}{c} = \frac{w\ L^2 e}{8800} = \frac{65 \times 18^2 \times 16}{8800} = 38.3.$$

$$I = \frac{w\ L^3 e}{21337} = \frac{65 \times 18^3 \times 16}{21337} = 284.3.$$

By Table 19 for $\frac{I}{c}$: $1\frac{5}{8}\times12$, 2×12, 3×10, 4×8.

By Table 20 for I: $1\frac{5}{8}\times14$, 2×12, 3×12, 4×10.

Hence the joists should either be $1\frac{5}{8}\times14$ or 2×12, full size.

PROBLEM 6. Joists for schoolroom floor, Case 5 *a*, Table 8. Joists of longleaf pine, 24 ft. long, set 12 ins. on centres, safely supporting total live and dead load of 102 lbs. per square foot of floor.

$$\frac{I}{c}=\frac{w\,L^2e}{11200}=\frac{102\times24^2\times12}{11200}=62.95.$$

$$I=\frac{w\,L^3e}{29606}=\frac{102\times24^3\times12}{29606}=571.5.$$

By Table 19 for $\frac{I}{c}$: 3×12, 4×10.

By Table 20 for I: 3×14, 4×12.

Therefore it is best to make the joists 3×14 ins.

PROBLEM 7. Mill construction for deck roof, Case 5 *b*, Table 9. Plank roof of $2\frac{5}{8}$ ins. shortleaf pine, which must safely support a total live and dead load of 40 lbs. per square foot. First find maximum safe distance between centres of supporting beams.

$$L=\frac{38.3\,t}{\sqrt{w}}=\frac{38.3\times2.625}{\sqrt{40}}=15.89\text{ ft. on centres.}$$

$$L=\frac{12.1\,t}{\sqrt[3]{w}}=\frac{12.1\times2.625}{\sqrt[3]{40}}=9.29\text{ ft. on centres.}$$

Therefore, the supporting beams cannot be safely set over 9.4 ft. on centres.

PROBLEM 8. Mill roof beams, Case 5, Table 7. Assuming the roof beams to be set 8 ft. on centres and to be of shortleaf pine also, and 16 ft. in clear length.

$W = 8 \times 16 \times 42 = 5376$ lbs. $= 2.688$ tons, allowing 2 lbs. per square foot for average weight of roof beams.

$$\frac{I}{c} = 2.730\ W\ L = 2.730 \times 2.688 \times 16 = 117.4.$$

$$I = 1.125\ W\ L^2 = 1.125 \times 2.688 \times 16^2 = 774.4.$$

By Table 19: 4×14, 6×12, 8×10.
By Table 20: 4×14, 6×12, 8×12.
Therefore 6×12 beams are preferable.

PROBLEM 9. Mill roof girders, Case 4, Table 6. Assuming that the posts are 16 ft. on centres, that one intermediate beam is supported at middle of girder, for shortleaf pine girders.

$$\frac{I}{c} = 5.45\ W\ L = 5.45 \times 2.688 \times 16 = 234.4.$$

$$I = 1.802\ W\ L^2 = 1.802 \times 2.688 \times 16^2 = 1240.3.$$

By Table 19: 6×16, 8×14, 10×12.
By Table 20: 6×14, 8×14, 10×12.
Hence it will be best to make these girders 8×14 ins.

27. Cast-iron Lintels.

Although lintels composed of steel shapes are now generally employed to span openings in masonry walls, cast-iron lintels are still frequently used for this purpose. But only certain stock sections and sizes are usually furnished by the larger foundries, since a specially made pattern would usually make the cost of a few lintels prohibitive. Tables 21, 22, and 23 comprise the standard forms and dimensions of lintels usually furnished. For these have been carefully computed their properties,

i.e., the numerical values of $\frac{I}{c}$, I, and c = distance in inches from bottom of lintel section to its horizontal gravity axis. Thus, it now becomes possible to apply the formulas previously given to determine the required cross-section of a cast-iron lintel as easily as to obtain the dimensions of a beam of wood or of steel shapes.

PROBLEM 10. An inverted T-lintel is 16 ft. long with a section 8×12 ins. and $1\frac{1}{4}$ in. metal. Determine its safe uniform load W.

By Table 22: $\frac{I}{c} = 58.2$; $I = 120.8$. Case 5, Table 7.

$$W = \frac{I}{c} \times \frac{1.00}{L} = 58.2 \times \frac{1.00}{16} = 3.637 \text{ tons.}$$

$$W = 11.85\frac{I}{L^2} = 11.85 \times \frac{120.8}{16^2} = 5.592 \text{ tons.}$$

Therefore, the maximum safe uniform load of the lintel = 3.637 tons.

PROBLEM 11. Box lintel, with two webs and uniformly loaded. Clear span of 12 ft. and must safely support a brick wall 12 ins. thick and 51 ft. high, weighing 120 lbs. per cubic foot.

Weight of wall $= 12 \times 5\frac{1}{2} \times 120 = 7920$ lbs. $= 3.96$ tons.

$$\text{Then } \frac{I}{c} = 1.000\,W\,L = 1 \times 3.96 \times 12 = 47.52.$$

$$I = 0.084\,WL^2 = 0.084 \times 3.96 \times 12^2 = 47.91.$$

By Table 21 a box lintel $8 \times 12 \times \frac{3}{4}$ ins. metal will be ample.

PROBLEM 12. Box lintel with three webs supporting brick wall. Span 16 ft. and wall 24 ins. thick and solid.

If the lintel be shored up until the mortar sets properly, it is generally assumed that the volume of the brick wall

actually supported by the lintel is that included below lines drawn at 60° through each end of the clear span of the lintel. In this case the altitude of this triangle $= \frac{16}{2}$ tan 60° = 13.86 ft.

$$\text{Volume of brickwork} = \frac{13.86 \times 16.0 \times 2}{2} = 221.76 \text{ cu. ft.}$$

$$\text{Weight} = 221.76 \times 120 = 26611 \text{ lbs.} = 13.30 \text{ tons.}$$

The ordinary formulas given for such a mode of loading are

$$\frac{P\,l}{6} = \frac{S\,I}{c} \quad \text{and} \quad \Delta = \frac{P\,l^3}{60\,E'I}.$$

Transforming these into simplified formulas in the manner explained in Art. 4, we obtain the following formulas for this form of loading on cast-iron lintel:

$$\frac{I}{c} = 1.333\,W\,L \quad \text{and} \quad I = 0.108\,W\,L^2.$$

$$\text{Then } \frac{I}{c} = 1.333\,W\,L = 1.333 \times 13.306 \times 16 = 283.8.$$

$$I = 0.108\,W\,L^2 = 0.108 \times 13.306 \times 16^2 = 359.5.$$

By Table 23 a lintel $12 \times 24 \times 1\frac{1}{2}$ ins. metal will suffice.

PROBLEM 13. Sheathing of roof. Shortleaf pine $\frac{7}{8}$-in. thick. Inclination of roof 35°. Slated on felt and sheathing.

p = 10 lbs. (slates) + 1 lb. (felt) + 3 lbs. (sheathing) = 14 lbs. per inclined square foot.

s = 15 lbs. per horizontal square foot.
$s \cos i°$ = 12.3 lbs. per inclined square foot.

w = 31.1 lbs. per inclined square foot (medium exposure).

Then $(14+12.3) \cos 35° = 21.6$ lbs. = normal component $p+s$ per inclined square foot. And

$$14 \cos 35° + 31.1 = 42.8 \text{ lbs.} = \text{normal component } p+w \text{ per square foot.}$$

$$14 \sin 35° + 0.00 = 8.0 \text{ lbs.} = \text{parallel component } p+w \text{ per square foot.}$$

The maximum normal component = 42.8 lbs. is to be taken, and the parallel component 8.0 lbs. may be neglected, because resisted by edgewise stiffness of the sheathing. By formulas for Case 5 *b*:

$$L = \frac{38.3\,t}{\sqrt{w}} = \frac{38.3 \times 0.875}{\sqrt{42.8}} = 5.06 \text{ ft. on centres on rafters.}$$

$$L = \frac{12.1\,t}{\sqrt[3]{w}} = \frac{12.1 \times 0.875}{\sqrt[3]{42.8}} = 3.02 \text{ ft. on centres of rafters.}$$

Hence the rafters cannnot be placed over 3 ft. on centres.

PROBLEM 14. Rafters. Case 5 *a*. Shortleaf pine. The rafters of the same roof are 12.5 ft. long, and their weight averages 3 lbs. per square foot of inclined surfaces.

Then $p = 14+3 = 17$ lbs. per inclined square foot of roof.

$(17+12.3) \cos 35° = 24.0$ lbs. = normal component of $p+s$.

$17 \cos 35° + 31.1 = 45.0$ lbs. = normal component of $p+w$.

$17 \sin 35° + 0.00 = 9.8$ lbs. = parallel component of $p+w$.

1. Assume that rafters are set 3 ft. on centres.

$$\frac{I}{c} = \frac{w\,L^2 e}{8800} = \frac{45 \times 12.5^2 \times 36}{8800} = 28.8.$$

$$I = \frac{w\,L^2 e}{21337} = \frac{45 \times 12.5^3 \times 36}{21337} = 148.3.$$

By Table 19: $1\frac{5}{8} \times 12$, 2×10, 3×8, 4×8.

By Table 20: $1\frac{5}{8} \times 12$, 2×10, 3×10, 4×8.

It would be most economical to use 2×10 rafters if full size. But these would look heavy, and would have a better appearance if set closer and made smaller.

2. Assume a section $1\frac{5}{8}\times8$ and determine e.

By Table 19: $\frac{I}{c}=17$; and by Table 20: $I=79$, for this section.

By formulas for e, Case 5 a, Table 8.

$$e=\frac{I}{c}\times\frac{8800}{w\,L^2}=\frac{17\times8800}{45\times12.5^2}=34.7 \text{ ins. on centres of rafters.}$$

$$e=\frac{21337\,I}{w\,L^3}=\frac{21337\times79}{45\times12.5^3}=19.2 \text{ ins. on centres of rafters.}$$

Best use $1\frac{5}{8}$-in. rafters set 18 ins. on centres.

Then $\Delta=\frac{w\,L^4e}{640200\,I}=\frac{45\times12.5^4\times18}{640200\times79}=0.391$ in. = maximum deflection.

Also $\frac{9.8\times1.5\times12.5}{2\times2000}=0.046$ ton = longitudinal compression at mid-length of the rafter due to parallel component of its load.

And $\frac{0.046}{1\frac{5}{8}\times8}=0.028$ ton per sq. in. compression there.

Then $0.028\left(1+\frac{6\,\Delta}{d}\right)=0.028\left(1+\frac{6\times0.391}{8}\right)=0.0239=$ maximum fibre stress due to longitudinal compression.

Also $0.55-0.0239=0.526=$ maximum safe fibre stress for supporting transverse load on rafter.

Substituting this value in the general formula of Case 5 a for safety against rupture:

$$\frac{I}{c}=\frac{w\,L^2e}{16000\,F}=\frac{45\times12.5^2\times18}{16000\times0.526}=15.$$

Since this is less than the actual value of $\frac{I}{c}=17$ for $1\frac{5}{8}\times 8$ section, this size will amply resist both normal and parallel components of loading.

This example shows that in ordinary cases the parallel component of the loading on rafters may be neglected.

PROBLEM 15. Purlins of roof, one to a panel. Length 16 ft., set normal to inclined surface.

1. Assume shortleaf pine timber, average weight 3 lbs. per inclined square foot.

$$p = 17+3 = 20 \text{ lbs. per inclined square foot.}$$

$(20+12.3)\cos 35° = 26.4$ lbs. = normal component of $p+s$.
$20\cos 35°+31.1 = 47.5$ lbs. = normal component of $p+w$.
$20\sin 35°+0 = 11.5$ lbs. = parallel component of $p+w$.
$16\times 12.5 = 200$ sq.ft. of inclined surface supported by one purlin.

$W' = 200\times 47.5 = 9500$ lbs. $= 4.75$ tons = normal loading on purlin.

$W'' = 200\times 11.5 = 2300$ lbs. $= 1.15$ tons = parallel loading on purlin.

a. For normal loading W'.

$$\frac{I}{c} = 2.730\, W\, L = 2.730\times 4.75\times 16 = 207.5.$$

$$I = 1.125\, W\, L^2 = 1.125\times 4.75\times 16^2 = 1368.$$

By Table 19: 4×18, 6×16, 8×14, 10×12.
By Table 20: 4×16, 6×14, 8×14, 10×12.

b. For parallel loading W''.

$$\frac{I}{c} = 2.730\, W\, L = 2.730\times 1.15\times 16 = 50.2.$$

$$I = 1.125\, W\, L^2 = 1.125\times 1.15\times 16^2 = 331.2.$$

By Table 19: 18×6, 16×6, 14×6, 12×6, 10×6.
By Table 20: 18×8, 16×8, 14×8, 12×8, 10×8.

Hence 8×14 might suffice for the dimensions required by both loadings.

Since the neutral axis of the cross-section of the purlin cannot coincide with its minor axis in this case, it becomes necessary to determine the actual maximum fibre stresses occurring in the corners most distant from the neutral axis, by the formula of Art. 25.

By Table 20, for 8×14 section, $I_y = 1829$; for 14×8 section, $I_x = 597$.

$$0.75\,L\left(\frac{W'd}{I_y}+\frac{W''b}{I_x}\right)=0.75\times16\left(\frac{4.75\times14}{1829}+\frac{1.15\times8}{597}\right)=0.622$$

ton per square inch equals actual maximum fibre stress, which exceeds the maximum safe fibre stress of 0.55 ton per square inch for shortleaf pine.

Hence it will be necessary to enlarge the section of the purlin, say, to 10×14.

By Table 20, for 10×14, $I_y=2287$; for 14×10, $I_x=1167$.

Then $0.65\times16\left(\frac{4.75\times14}{2287}+\frac{1.15\times10}{1187}\right)=0.449$ ton per sq. in., which is amply safe.

2. Assume purlin composed of two latticed steel channels spaced apart to make purlin equally stiff in both directions. Average weight of steel purlins 4 lbs. per inclined square foot of roof.

Then $p=17+4=21$ lbs. per inclined square foot.

$21\cos35°+31.1 = 48.3$ lbs. = normal component of $p+w$.

$21\sin35°+0.00 = 12.0$ lbs. = parallel component of $p+w$.

$W' = 200\times48.3 = 9660$ lbs. = 4.83 tons = normal loading.

$W'' = 200\times12.0 = 2400$ lbs. = 1.20 tons = parallel loading.

a. For normal loading.

$$\frac{I}{c} = 0.187\, W\, L = 0.187 \times 4.83 \times 16 = 14.4$$

$$I = 0.047\, W\, L^2 = 0.047 = 4.83 \times 16^2 = 58.1.$$

By Cambria, 2, 8 in., $11\frac{1}{4}$ lb. channels will suffice.

It is evidently unnecessary here to compute $\frac{I}{c}$ and I for the parallel loading, since their values are much smaller and the purlin is made to be equally stiff in both directions.

But it will be well to apply the formula to determine the actual maximum fibre stresses occurring in the section.

Here $I_y = I_x = 64.6$, and $b = 9.43$ ins., = width of two flanges + spacing.

$$0.75\, L\left(\frac{W'd}{I_y} + \frac{W''b}{I_x}\right) = 0.75 \times 16\left(\frac{4.83 \times 8}{64.6} + \frac{1.20 \times 9.43}{64.6}\right) = 9.28$$

tons per square inch, which exceeds the maximum safe fibre stress of 8 tons for steel.

Hence, the purlin must be composed of 2, 8 in., $13\frac{3}{4}$ lb. channels, which will be amply strong.

3. Assume that purlin is composed of a single I-beam with supporting rods as required.

Since for W', $\frac{I}{c} = 14.4$, and $I = 58.1$, as already found, use 1, 8 in., $20\frac{1}{4}$ lb. I-beam, for which sidewise $\frac{I}{c} = \frac{4.04}{2.04} = 1.98$ and $I = 4.04$. Then by formulas for Case 5:

$$L = \frac{I}{c} \times \frac{5.333}{W''} = \frac{1.98 \times 5.333}{1.20} = 8.80 \text{ ft. between supporting rods.}$$

$$L = 4.64\sqrt{\frac{I}{W''}} = 4.64\sqrt{\frac{4.04}{1.20}} = 10.22 \text{ ft. between rods.}$$

Therefore, one supporting rod at mid-length of purlin will suffice, and this will be much lighter and more economical than the latticed purlin composed of two channels.

Since this beam is supported sidewise at the middle of its length, the maximum fibre stress at that point is only that produced by W'.

Transposing for F the general formula in Case 5:

$$\frac{I}{c} = \frac{1.5\,W\,L}{F},$$

we find

$$F = \frac{1.5\,W\,L}{\frac{I}{c}} = \frac{1.5 \times 4.83 \times 16}{15} = 7.73 \text{ tons per square inch,}$$

which is entirely safe there.

Apply formula for actual maximum fibre stress, the free span being here reduced to 8 ft. instead of 16 ft., and W' and W'' are likewise halved.

$$0.75\,L\left(\frac{W'd}{I_y} + \frac{W''b}{I_x}\right) = 0.75 \times 8\left(\frac{2.42 \times 8}{60.2} + \frac{0.60 \times 4.08}{4.04}\right) =$$

5.57 tons per square inch, which is amply safe, so that this I-beam may be used.

TABLES

CASE 1. BEAM CANTILEVER. LOAD AT FREE END. TABLE 1

General	Steel	Cast Iron	Fir, Wash.	Hemlock
	For maximum safe fibre stress F.			
$\frac{I}{c}=\frac{12WL}{F}$	$1.5WL$	$8.0WL$	$17.2WL$	$26.7WL$
$W=\frac{I}{c}\times\frac{F}{12L}$	$\frac{I}{c}\times\frac{0.667}{L}$	$\frac{I}{c}\times\frac{0.125}{L}$	$\frac{I}{c}\times\frac{0.058}{L}$	$\frac{I}{c}\times\frac{0.038}{L}$
$L=\frac{I}{c}\times\frac{F}{12W}$	$\frac{I}{c}\times\frac{0.667}{W}$	$\frac{I}{c}\times\frac{0.125}{W}$	$\frac{I}{c}\times\frac{0.058}{W}$	$\frac{I}{c}\times\frac{0.038}{W}$
	For maximum safe deflection $\frac{L}{30}$.			
$I=17280\frac{WL^2}{E}$	$1.192WL^2$	$2.160WL^2$	$24.70WL^2$	$38.45WL^2$
$W=\frac{EI}{17280L^2}$	$0.840\frac{I}{L^2}$	$0.463\frac{I}{L^2}$	$0.041\frac{I}{L^2}$	$0.026\frac{I}{L^2}$
$L=\sqrt{\frac{EI}{17280W}}$	$0.917\sqrt{\frac{I}{W}}$	$0.680\sqrt{\frac{I}{W}}$	$0.202\sqrt{\frac{I}{W}}$	$0.161\sqrt{\frac{I}{W}}$
	For directly computing I from $\frac{I}{c}$.			
$I=\frac{I}{c}\times\frac{1440LF}{E}$	$\frac{I}{c}\times 0.795L$	$\frac{I}{c}\times 0.270L$	$\frac{I}{c}\times 1.44L$	$\frac{I}{c}\times 1.44L$
	For maximum safe fibre stress and deflection.			
$L=\frac{Ec}{1440F}$	$1.26c$	$3.71c$	$0.70c$	$0.70c$
	Actual maximum deflection.			
$\Delta=\frac{576WL^3}{EI}$	$\frac{WL^3}{25.20I}$	$\frac{WL^3}{13.89I}$	$\frac{WL^3}{1.215I}$	$\frac{WL^3}{0.782I}$

CASE 1. BEAM CANTILEVER. LOAD AT FREE END. TABLE 1

Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
For maximum safe fibre stress F.				
$\frac{I}{c}=18.5WL$	$17.2WL$	$21.8WL$	$26.7WL$	$21.8WL$
$W=\frac{I}{c}\times\frac{0.054}{L}$	$\frac{I}{c}\times\frac{0.058}{L}$	$\frac{I}{c}\times\frac{0.046}{L}$	$\frac{I}{c}\times\frac{0.042}{L}$	$\frac{I}{c}\times\frac{0.046}{L}$
$L=\frac{I}{c}\times\frac{0.054}{W}$	$\frac{I}{c}\times\frac{0.058}{W}$	$\frac{I}{c}\times\frac{0.046}{W}$	$\frac{I}{c}\times\frac{0.042}{W}$	$\frac{I}{c}\times\frac{0.046}{W}$
For maximum safe deflection $\frac{L}{30}$.				
$I=23.1WL^2$	$20.4WL^2$	$28.8WL^2$	$34.6WL^2$	$26.6WL^2$
$W=0.043\frac{I}{L^2}$	$0.049\frac{I}{L^2}$	$0.035\frac{I}{L^2}$	$0.029\frac{I}{L^2}$	$0.38\frac{I}{L^2}$
$L=0.207\sqrt{\frac{I}{W}}$	$0.221\sqrt{\frac{I}{W}}$	$0.187\sqrt{\frac{I}{W}}$	$0.170\sqrt{\frac{I}{W}}$	$0.195\sqrt{\frac{I}{W}}$
For directly computing I from $\frac{I}{c}$.				
$I=\frac{I}{c}\times1.25L$	$\frac{I}{c}\times1.19L$	$\frac{I}{c}\times1.32L$	$\frac{I}{c}\times1.30L$	$\frac{I}{c}\times1.22L$
For maximum safe fibre stress and deflection.				
$L=0.80c$	$0.84c$	$0.76c$	$0.77c$	$0.82c$
Actual maximum deflection.				
$\Delta=\frac{WL^3}{1.32I}$	$\frac{WL^3}{1.48I}$	$\frac{WL^3}{1.04I}$	$\frac{WL^3}{0.87I}$	$\frac{WL^3}{1.13I}$

CASE 2. BEAM CANTILEVER. LOAD UNIFORM. TABLE 2

General	Steel	Cast Iron	Fir, Wash.	Hemlock
	For maximum safe fibre stress F.			
$\frac{I}{c}=\frac{6WL}{F}$	$0.75WL$	$4.00WL$	$8.58WL$	$13.33WL$
$W=\frac{I}{c}\times\frac{F}{6L}$	$\frac{I}{c}\times\frac{1.333}{L}$	$\frac{I}{c}\times\frac{0.250}{L}$	$\frac{I}{c}\times\frac{0.117}{L}$	$\frac{I}{c}\times\frac{0.075}{L}$
$L=\frac{I}{c}\times\frac{F}{6W}$	$\frac{I}{c}\times\frac{1.333}{W}$	$\frac{I}{c}\times\frac{0.250}{W}$	$\frac{I}{c}\times\frac{0.117}{W}$	$\frac{I}{c}\times\frac{0.075}{W}$
	For maximum safe deflection $\frac{L}{30}$.			
$I=\frac{6480WL^2}{E}$	$0.447WL^2$	$0.810WL^2$	$9.26WL^2$	$14.40WL^2$
$W=\frac{EI}{6480L^2}$	$2.240\frac{I}{L^2}$	$1.235\frac{I}{L^2}$	$0.108\frac{I}{L^2}$	$0.069\frac{I}{L^2}$
$L=\sqrt{\frac{EI}{6480W}}$	$1.50\sqrt{\frac{I}{W}}$	$1.11\sqrt{\frac{I}{W}}$	$0.33\sqrt{\frac{I}{W}}$	$0.26\sqrt{\frac{I}{W}}$
	For directly computing I from $\frac{I}{c}$.			
$I=\frac{I}{c}\times\frac{1080LF}{E}$	$\frac{I}{c}\times0.596L$	$\frac{I}{c}\times0.203L$	$\frac{I}{c}\times1.08L$	$\frac{I}{c}\times1.08L$
	For maximum safe fibre stress and deflection.			
$L=\frac{Ec}{1080F}$	$1.68c$	$4.94c$	$0.93c$	$0.93c$
	Actual maximum deflection.			
$\Delta=\frac{216WL^3}{EI}$	$\frac{WL^3}{67.20I}$	$\frac{WL^3}{37.05I}$	$\frac{WL^3}{3.24I}$	$\frac{WL^3}{2.08I}$

CASE 2. BEAM CANTILEVER. LOAD UNIFORM. TABLE 2

	Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
For maximum safe fibre stress F.					
	$\frac{I}{c}=9.28WL$	$8.54WL$	$10.91WL$	$13.33WL$	$10.91WL$
	$W=\frac{I}{c}\times\frac{0.108}{L}$	$\frac{I}{c}\times\frac{0.117}{L}$	$\frac{I}{c}\times\frac{0.092}{L}$	$\frac{I}{c}\times\frac{0.075}{L}$	$\frac{I}{c}\times\frac{0.092}{L}$
	$L=\frac{I}{c}\times\frac{0.108}{W}$	$\frac{I}{c}\times\frac{0.117}{W}$	$\frac{I}{c}\times\frac{0.092}{W}$	$\frac{I}{c}\times\frac{0.075}{W}$	$\frac{I}{c}\times\frac{0.092}{W}$
For maximum safe deflection $\frac{L}{30}$.					
	$I=8.65WL^2$	$7.63WL^2$	$10.80WL^2$	$12.96WL^2$	$9.98WL^2$
	$W=0.116\frac{I}{L^2}$	$0.131\frac{I}{L^2}$	$0.093\frac{I}{L^2}$	$0.077\frac{I}{L^2}$	$0.100\frac{I}{L^2}$
	$L=0.34\sqrt{\frac{I}{W}}$	$0.36\sqrt{\frac{I}{W}}$	$0.31\sqrt{\frac{I}{W}}$	$0.28\sqrt{\frac{I}{W}}$	$0.32\sqrt{\frac{I}{W}}$
For directly computing I from $\frac{I}{c}$.					
	$I=\frac{I}{c}\times 0.938L$	$\frac{I}{c}\times 0.891L$	$\frac{I}{c}\times 0.991L$	$\frac{I}{c}\times 0.973\,L$	$\frac{I}{c}\times 0.915L$
For maximum safe fibre stress and deflection					
	$L=1.07c$	$1.12c$	$1.01c$	$1.03c$	$1.09c$
Actual maximum deflection.					
	$\Delta=\frac{WL^3}{3.47I}$	$\frac{WL^3}{3.94I}$	$\frac{WL^3}{2.78I}$	$\frac{WL^3}{2.32I}$	$\frac{WL^3}{3.01I}$

CASE 2A. JOIST CANTILEVER. LOAD UNIFORM. TABLE 3

General	Steel	Cast Iron	Fir, Wash.	Hemlock
	For maximum safe fibre stress F.			
$\frac{I}{c}=\frac{wL^2e}{4000F}$	$\frac{wL^2e}{32000}$	$\frac{wL^2e}{6000}$	$\frac{wL^2e}{2800}$	$\frac{wL^2e}{1800}$
$w=\frac{I}{c}\times\frac{4000F}{L^2e}$	$\frac{I}{c}\times\frac{32000}{L^2e}$	$\frac{I}{c}\times\frac{6000}{L^2e}$	$\frac{I}{c}\times\frac{2800}{L^2e}$	$\frac{I}{c}\times\frac{1800}{L^2e}$
$e=\frac{I}{c}\times\frac{4000F}{wL^2}$	$\frac{I}{c}\times\frac{32000}{wL^2}$	$\frac{I}{c}\times\frac{6000}{wL^2}$	$\frac{I}{c}\times\frac{2800}{wL^2}$	$\frac{I}{c}\times\frac{1800}{wL^2}$
$L=\sqrt{\frac{I}{c}\times\frac{4000F}{we}}$	$178.9\sqrt{\frac{I}{wec}}$	$77.5\sqrt{\frac{I}{wec}}$	$52.9\sqrt{\frac{I}{wec}}$	$42.4\sqrt{\frac{I}{wec}}$
	For maximum safe deflection $\frac{L}{30}$.			
$I=\frac{wL^3e}{3.70E}$	$\frac{wL^3e}{53650}$	$\frac{wL^3e}{29580}$	$\frac{wL^3e}{2590}$	$\frac{wL^3e}{1665}$
$w=\frac{3.70EI}{L^3e}$	$\frac{53650I}{L^3e}$	$\frac{29580I}{L^3e}$	$\frac{2590I}{L^3e}$	$\frac{1665I}{L^3e}$
$e=\frac{3.70EI}{wL^3}$	$\frac{53650I}{wL^3}$	$\frac{29580I}{wL^3}$	$\frac{2590I}{wL^3}$	$\frac{1665I}{wL^3}$
$L=\sqrt[3]{\frac{3.70EI}{we}}$	$37.7\sqrt[3]{\frac{I}{we}}$	$30.9\sqrt[3]{\frac{I}{we}}$	$13.7\sqrt[3]{\frac{I}{we}}$	$11.9\sqrt[3]{\frac{I}{we}}$
	For directly computing I from $\frac{I}{c}$.			
$I=\frac{I}{c}+\frac{1080LF}{E}$	$\frac{I}{c}\times 0.596L$	$\frac{I}{c}\times 0.203L$	$\frac{I}{c}\times 1.08L$	$\frac{I}{c}\times 1.08L$
	For maximum safe fibre stress and deflection.			
$L=\frac{Ec}{1080F}$	$1.68c$	$4.94c$	$0.93c$	$0.93c$
	Actual maximum deflection.			
$\Delta=\frac{wL^4e}{111EI}$	$\frac{wL^4e}{1609500}$	$\frac{wL^4e}{888000}$	$\frac{wL^4e}{77700}$	$\frac{wL^4e}{49950}$

CASE 2A. JOIST CANTILEVER. LOAD UNIFORM. TABLE 3

	Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
	For maximum safe fibre stress F.				
$\frac{I}{c}=$	$\frac{wL^2e}{2600}$	$\frac{wL^2e}{2800}$	$\frac{wL^2e}{2200}$	$\frac{wL^2e}{1800}$	$\frac{wL^2e}{2200}$
$w=$	$\frac{I}{c}\times\frac{2600}{L^2e}$	$\frac{I}{c}\times\frac{2800}{L^2e}$	$\frac{I}{c}\times\frac{2200}{L^2e}$	$\frac{I}{c}\times\frac{1800}{L^2e}$	$\frac{I}{c}\times\frac{2200}{L^2e}$
$e=$	$\frac{I}{c}\times\frac{2600}{wL^2}$	$\frac{I}{c}\times\frac{2800}{wL^2}$	$\frac{I}{c}\times\frac{2200}{wL^2}$	$\frac{I}{c}\times\frac{1800}{wL^2}$	$\frac{I}{c}\times\frac{2200}{wL^2}$
$L=$	$51.0\sqrt{\frac{I}{wec}}$	$52.9\sqrt{\frac{I}{wec}}$	$46.9\sqrt{\frac{I}{wec}}$	$42.4\sqrt{\frac{I}{wec}}$	$46.9\sqrt{\frac{I}{wec}}$
	For maximum safe deflection $\frac{L}{30}$.				
$I=$	$\frac{wL^3e}{2775}$	$\frac{wL^3e}{3145}$	$\frac{wL^3e}{2220}$	$\frac{wL^3e}{1850}$	$\frac{wL^3e}{2405}$
$w=$	$\frac{2775I}{L^3e}$	$\frac{3145I}{L^3e}$	$\frac{2220I}{L^3e}$	$\frac{1850I}{L^3e}$	$\frac{2405I}{L^3e}$
$e=$	$\frac{2775I}{wL^3}$	$\frac{3145I}{wL^3}$	$\frac{2220I}{wL^3}$	$\frac{1850I}{wL^3}$	$\frac{2405I}{wL^3}$
$L=$	$14.0\sqrt[3]{\frac{I}{we}}$	$14.7\sqrt[3]{\frac{I}{we}}$	$13.1\sqrt[3]{\frac{I}{we}}$	$12.3\sqrt[3]{\frac{I}{we}}$	$13.4\sqrt[3]{\frac{I}{we}}$
	For directly computing I from $\frac{I}{c}$.				
$I=$	$\frac{I}{c}\times0.936L$	$\frac{I}{c}\times0.890L$	$\frac{I}{c}\times0.990L$	$\frac{I}{c}\times0.973L$	$\frac{I}{c}\times0.914L$
	For maximum safe fibre stress and deflection.				
$L=$	$1.07c$	$1.12c$	$1.01c$	$1.03c$	$1.09c$
	Actual maximum deflection.				
$\Delta=$	$\frac{wL^4e}{83250}$	$\frac{wL^4e}{94350}$	$\frac{wL^4e}{66600}$	$\frac{wL^4e}{55500}$	$\frac{wL^4e}{72150}$

CASE 2B FLOORING CANTILEVER. LOAD UNIFORM. TABLE 4

General	Steel	Cast Iron	Fir, Wash.	Hemlock
		For maximum safe fibre stress F.		
$t=\sqrt{\frac{wL^2}{667F}}$	....	....	$\frac{L\sqrt{w}}{21.6}$	$\frac{L\sqrt{w}}{17.3}$
$w=\frac{667F}{L^2}$	....	....	$\frac{466.9}{L^2}$	$\frac{300.2}{L^2}$
$L=\sqrt{\frac{667Ft^2}{w}}$	....	....	$\frac{21.6t}{\sqrt{w}}$	$\frac{17.3t}{\sqrt{w}}$
		For maximum safe deflection $\frac{L}{30}$.		
$t=\sqrt[3]{\frac{3.24wL^3}{E}}$	....	....	$\frac{L\sqrt[3]{w}}{6.00}$	$\frac{L\sqrt[3]{w}}{5.05}$
$w=\frac{Et^3}{3.24L^3}$	....	....	$216\,\frac{t^3}{L^3}$	$128.9\,\frac{t^3}{L^3}$
$L=\sqrt[3]{\frac{Et^3}{3.24w}}$	....	....	$\frac{6.00t}{\sqrt[3]{w}}$	$\frac{5.05t}{\sqrt[3]{w}}$
		For maximum safe fibre stress and deflection.		
$L=\frac{Et}{2160F}$	....	....	$0.47t$	$0.47t$
		Actual maximum deflection.		
$\Delta=\frac{wL^4}{9.26Et^3}$	....	....	$\frac{wL^4}{6482t^3}$	$\frac{wL^4}{4167t^3}$

CASE 2B. FLOORING CANTILEVER. LOAD UNIFORM. TABLE 4

	Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
	For maximum safe fibre stress F.				
$t=$	$\frac{L\sqrt{w}}{20.8}$	$\frac{L\sqrt{w}}{21.6}$	$\frac{L\sqrt{w}}{19.2}$	$\frac{L\sqrt{w}}{17.3}$	$\frac{L\sqrt{w}}{19.2}$
$w=$	$\frac{433.6}{L^2}$	$\frac{466.9}{L^2}$	$\frac{366.9}{L^2}$	$\frac{300.2}{L^2}$	$\frac{366.9}{L^2}$
$L=$	$\frac{20.8t}{\sqrt{w}}$	$\frac{21.6t}{\sqrt{w}}$	$\frac{19.2t}{\sqrt{w}}$	$\frac{17.3t}{\sqrt{w}}$	$\frac{19.2t}{\sqrt{w}}$
	For maximum safe deflection $\frac{L}{30}$.				
$t=$	$\frac{L\sqrt[3]{w}}{6.14}$	$\frac{L\sqrt[3]{w}}{6.40}$	$\frac{L\sqrt[3]{w}}{5.70}$	$\frac{L\sqrt[3]{w}}{5.37}$	$\frac{L\sqrt[3]{w}}{5.86}$
$w=$	$231.6\frac{t^3}{L^3}$	$262.5\frac{t^3}{L^3}$	$185.2\frac{t^3}{L^3}$	$154.3\frac{t^3}{L^3}$	$201.5\frac{t^3}{L^3}$
$L=$	$\frac{6.14t}{\sqrt[3]{w}}$	$\frac{6.40t}{\sqrt[3]{w}}$	$\frac{5.70t}{\sqrt[3]{w}}$	$\frac{5.37t}{\sqrt[3]{w}}$	$\frac{5.86t}{\sqrt[3]{w}}$
	For maximum safe fibre stress and deflection.				
$L=$	$0.54t$	$0.56t$	$0.51t$	$0.52t$	$0.55t$
	Actual maximum deflection.				
$\Delta=$	$\frac{wL^4}{6945t^3}$	$\frac{wL^4}{7871t^3}$	$\frac{wL^4}{5556t^3}$	$\frac{wL^4}{4630t^3}$	$\frac{wL^4}{6019t^3}$

CASE 3. BEAM CANTILEVER. LOAD IRREGULAR. TABLE 5

General	Steel	Cast Iron	Fir, Wash.	Spruce
	For maximum fibre stress F.			
$\frac{I}{c}=\frac{12M}{F}$	$1.50M$	$8.00M$	$17.16M$	$26.70M$
$M=\frac{I}{c}\times\frac{F}{12}$	$0.667\frac{I}{c}$	$0.125\frac{I}{c}$	$0.058\frac{I}{c}$	$0.038\frac{I}{c}$
	For maximum safe deflection $\frac{L}{30}$. Load at free end.			
$I=\frac{17280ML}{E}$	$1.193ML$	$2.160ML$	$24.70ML$	$38.45ML$
$M=\frac{EI}{17280L}$	$0.840\frac{I}{L}$	$0.463\frac{I}{L}$	$0.041\frac{I}{L}$	$0.026\frac{I}{L}$
$L=\frac{EI}{17280M}$	$0.840\frac{I}{M}$	$0.463\frac{I}{M}$	$0.041\frac{I}{M}$	$0.026\frac{I}{M}$
	For directly computing I from $\frac{I}{c}$.			
$I=\frac{I}{c}\times\frac{1440LF}{E}$	$\frac{I}{c}\times0.795L$	$\frac{I}{c}\times0.270L$	$\frac{I}{c}\times1.44L$	$\frac{I}{c}\times1.44L$
	Actual maximum deflection.			
$\Delta=\frac{576ML^2}{EI}$	$\frac{ML^2}{25.20I}$	$\frac{ML^2}{13.89I}$	$\frac{ML^2}{1.215I}$	$\frac{ML^2}{0.782I}$
	For maximum safe deflection $\frac{L}{30}$. Load uniform.			
$I=\frac{12960ML}{E}$	$0.894ML$	$1.620ML$	$18.52ML$	$28.80ML$
$M=\frac{EI}{12960L}$	$1.120\frac{I}{L}$	$0.618\frac{I}{L}$	$0.054\frac{I}{L}$	$0.035\frac{I}{L}$
$L=\frac{EI}{12960M}$	$1.120\frac{I}{M}$	$0.618\frac{I}{M}$	$0.054\frac{I}{M}$	$0.035\frac{I}{M}$
	For directly computing I from $\frac{I}{c}$.			
$I=\frac{I}{c}\times\frac{1080LF}{E}$	$\frac{I}{c}\times0.596L$	$\frac{I}{c}\times0.203L$	$\frac{I}{c}\times1.08L$	$\frac{I}{c}\times1.08L$
	Actual maximum deflection.			
$\Delta=\frac{432ML^2}{EI}$	$\frac{ML^2}{33.60I}$	$\frac{ML^2}{18.53I}$	$\frac{ML^2}{1.62I}$	$\frac{ML^2}{1.04I}$

CASE 3. BEAM CANTILEVER. LOAD IRREGULAR. TABLE 5

Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
For maximum safe fibre stress F.				
$\frac{I}{c}=18.48M$	$17.16M$	$21.84M$	$26.70M$	$21.84M$
$M=0.054\frac{I}{c}$	$0.058\frac{I}{c}$	$0.046\frac{I}{c}$	$0.038\frac{I}{c}$	$0.046\frac{I}{c}$
For maximum safe deflection $\frac{L}{30}$. Load at free end.				
$I=23.07ML$	$20.36ML$	$28.85ML$	$34.60ML$	$26.62ML$
$M=0.043\frac{I}{L}$	$0.049\frac{I}{L}$	$0.035\frac{I}{L}$	$0.029\frac{I}{L}$	$0.038\frac{I}{L}$
$L=0.043\frac{I}{M}$	$0.049\frac{I}{M}$	$0.035\frac{I}{M}$	$0.029\frac{I}{M}$	$0.038\frac{I}{M}$
For directly computing I from $\frac{I}{c}$.				
$I=\frac{I}{c}\times1.25L$	$\frac{I}{c}\times1.19L$	$\frac{I}{c}\times1.32L$	$\frac{I}{c}\times1.30L$	$\frac{I}{c}\times1.22L$
Actual maximum deflection.				
$\Delta=\frac{ML^2}{1.32I}$	$\frac{ML^2}{1.48I}$	$\frac{ML^2}{1.04I}$	$\frac{ML^2}{0.87I}$	$\frac{ML^2}{1.13I}$
For maximum safe deflection $\frac{L}{30}$. Load uniform.				
$I=17.30ML$	$15.26ML$	$21.60ML$	$25.92ML$	$19.96ML$
$M=0.058\frac{I}{L}$	$0.066\frac{I}{L}$	$0.047\frac{I}{L}$	$0.039\frac{I}{L}$	$0.050\frac{I}{L}$
$L=0.058\frac{I}{M}$	$0.066\frac{I}{M}$	$0.047\frac{I}{M}$	$0.039\frac{I}{M}$	$0.050\frac{I}{M}$
For directly computing I from $\frac{I}{c}$.				
$I=\frac{I}{c}\times0.936L$	$\frac{I}{c}\times0.891L$	$\frac{I}{c}\times0.991L$	$\frac{I}{c}\times0.973L$	$\frac{I}{c}\times0.915L$
Actual maximum deflection.				
$\Delta=\frac{ML^2}{1.74I}$	$\frac{ML^2}{1.92I}$	$\frac{ML^2}{1.39I}$	$\frac{ML^2}{1.16I}$	$\frac{ML^2}{1.51I}$

CASE 4. BEAM SUPPORTED AT ENDS. LOAD AT MIDDLE

TABLE 6

General	Steel	Cast Iron	Fir, Wash.	Hemlock
For maximum safe fibre stress F.				
$\frac{I}{c}=\frac{3WL}{F}$	$0.375WL$	$2.000WL$	$4.29WL$	$6.67WL$
$W=\frac{I}{c}\times\frac{F}{3L}$	$\frac{I}{c}\times\frac{2.670}{L}$	$\frac{I}{c}\times\frac{0.500}{L}$	$\frac{I}{c}\times\frac{0.233}{L}$	$\frac{I}{c}\times\frac{0.150}{L}$
$L=\frac{I}{c}\times\frac{F}{3W}$	$\frac{I}{c}\times\frac{2.670}{W}$	$\frac{I}{c}\times\frac{0.500}{W}$	$\frac{I}{c}\times\frac{0.233}{W}$	$\frac{I}{c}\times\frac{0.150}{W}$
For maximum safe deflection $\frac{L}{30}$.				
$I=\frac{1080WL^2}{E}$	$0.075WL^2$	$0.135WL^2$	$1.544WL^2$	$2.403WL^2$
$W=\frac{EI}{1080L^2}$	$13.430\frac{I}{L^2}$	$7.410\frac{I}{L^2}$	$0.648\frac{I}{L^2}$	$0.417\frac{I}{L^2}$
$L=\sqrt{\frac{EI}{1080W}}$	$3.67\sqrt{\frac{I}{W}}$	$2.72\sqrt{\frac{I}{W}}$	$0.81\sqrt{\frac{I}{W}}$	$0.65\sqrt{\frac{I}{W}}$
For directly computing I from $\frac{I}{c}$.				
$I=\frac{I}{c}\times\frac{360LF}{E}$	$\frac{I}{c}\times0.199L$	$\frac{I}{c}\times0.068L$	$\frac{I}{c}\times0.360L$	$\frac{I}{c}\times0.360L$
For maximum safe fibre stress and deflection.				
$L=\frac{Ec}{360F}$	$5.04c$	$14.82c$	$2.78c$	$2.78c$
Actual maximum deflection.				
$\Delta=\frac{36WL^3}{EI}$	$\frac{WL^3}{403I}$	$\frac{WL^3}{222I}$	$\frac{WL^3}{19.45I}$	$\frac{WL^3}{12.50I}$

CASE 4. BEAM SUPPORTED AT ENDS. LOAD AT MIDDLE.

TABLE 6

Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
For maximum safe fibre stress F.				
$\frac{I}{c}=4.61WL$	$4.29WL$	$5.45WL$	$6.67WL$	$5.45WL$
$W=\frac{I}{c}\times\frac{0.217}{L}$	$\frac{I}{c}\times\frac{0.233}{L}$	$\frac{I}{c}\times\frac{0.183}{L}$	$\frac{I}{c}\times\frac{0.150}{L}$	$\frac{I}{c}\times\frac{0.183}{L}$
$L=\frac{I}{c}\times\frac{0.217}{W}$	$\frac{I}{c}\times\frac{0.233}{W}$	$\frac{I}{c}\times\frac{0.183}{W}$	$\frac{I}{c}\times\frac{0.150}{W}$	$\frac{I}{c}\times\frac{0.183}{W}$
For maximum safe deflection $\frac{L}{30}$.				
$I=1.442WL^2$	$1.272WL^2$	$1.802WL^2$	$2.163WL^2$	$1.965WL^2$
$W=0.695\frac{I}{L^2}$	$0.787\frac{I}{L^2}$	$0.555\frac{I}{L^2}$	$0.463\frac{I}{L^2}$	$0.602\frac{I}{L^2}$
$L=0.834\sqrt{\frac{I}{W}}$	$0.887\sqrt{\frac{I}{W}}$	$0.745\sqrt{\frac{I}{W}}$	$0.681\sqrt{\frac{I}{W}}$	$0.776\sqrt{\frac{I}{W}}$
For directly computing I from $\frac{I}{c}$.				
$I=\frac{I}{c}\times 0.312L$	$\frac{I}{c}\times 0.296L$	$\frac{I}{c}\times 0.330L$	$\frac{I}{c}\times 0.324L$	$\frac{I}{c}\times 0.330L$
For maximum safe fibre stress and deflection.				
$L=3.20c$	$3.37c$	$3.03c$	$3.09c$	$3.29c$
Actual maximum deflection.				
$\frac{WL^3}{20.84I}$	$\frac{WL^3}{23.63I}$	$\frac{WL^3}{16.67I}$	$\frac{WL^3}{13.88I}$	$\frac{WL^3}{18.05I}$

CASE 5. BEAM SUPPORTED AT ENDS. LOAD UNIFORM

TABLE 7

General	Steel	Cast Iron	Fir, Wash.	Hemlock
For maximum safe fibre stress F.				
$\frac{I}{c}=\frac{1.5WL}{F}$	$0.187WL$	$1.000WL$	$2.144WL$	$3.336WL$
$W=\frac{I}{c}\times\frac{F}{1.5L}$	$\frac{I}{c}\times\frac{5.333}{L}$	$\frac{I}{c}\times\frac{1.000}{L}$	$\frac{I}{c}\times\frac{0.467}{L}$	$\frac{I}{c}\times\frac{0.300}{L}$
$L=\frac{I}{c}\times\frac{F}{1.5W}$	$\frac{I}{c}\times\frac{5.333}{W}$	$\frac{I}{c}\times\frac{1.000}{W}$	$\frac{I}{c}\times\frac{0.467}{W}$	$\frac{I}{c}\times\frac{0.300}{W}$
For maximum safe deflection $\frac{L}{30}$.				
$I=\frac{675WL^2}{E}$	$0.047WL^2$	$0.084WL^2$	$0.965WL^2$	$1.500WL^2$
$W=\frac{EI}{675L^2}$	$21.50\frac{I}{L^2}$	$11.85\frac{I}{L^2}$	$1.22\frac{I}{L^2}$	$0.67\frac{I}{L^2}$
$L=\sqrt{\frac{EI}{675W}}$	$4.64\sqrt{\frac{I}{W}}$	$3.44\sqrt{\frac{I}{W}}$	$1.10\sqrt{\frac{I}{W}}$	$0.82\sqrt{\frac{I}{W}}$
For directly computing I from $\frac{I}{c}$.				
$I=\frac{I}{c}\times\frac{450LF}{E}$	$\frac{I}{c}\times 0.248L$	$\frac{I}{c}\times 0.085L$	$\frac{I}{c}\times 0.450L$	$\frac{I}{c}\times 0.450L$
For maximum safe fibre stress and deflection.				
$L=\frac{Ec}{450F}$	$4.02c$	$11.90c$	$2.22c$	$2.22c$
Actual maximum deflection.				
$\Delta=\frac{22.5WL^3}{EI}$	$\frac{WL^3}{580I}$	$\frac{WL^3}{356I}$	$\frac{WL^3}{31.1I}$	$\frac{WL^3}{20.0I}$

CASE 5. BEAM SUPPORTED AT ENDS. LOAD UNIFORM

TABLE 7

Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
	For maximum safe fibre stress F.			
$\frac{I}{c}=2.310WL$	$2.144WL$	$2.730WL$	$3.336WL$	$2.730WL$
$W=\frac{I}{c}\times\frac{0.433}{L}$	$\frac{I}{c}\times\frac{0.467}{L}$	$\frac{I}{c}\times\frac{0.367}{L}$	$\frac{I}{c}\times\frac{0.300}{L}$	$\frac{I}{c}\times\frac{0.367}{L}$
$L=\frac{I}{c}\times\frac{0.433}{W}$	$\frac{I}{c}\times\frac{0.467}{W}$	$\frac{I}{c}\times\frac{0.367}{W}$	$\frac{I}{c}\times\frac{0.300}{W}$	$\frac{I}{c}\times\frac{0.367}{W}$
	For maximum safe deflection $\frac{L}{30}$.			
$I=0.900WL^2$	$0.795WL^2$	$1.125WL^2$	$1.350WL^2$	$1.038WL^2$
$W=1.11\frac{I}{L^2}$	$1.26\frac{I}{L^2}$	$0.89\frac{I}{L^2}$	$0.73\frac{I}{L^2}$	$0.96\frac{I}{L^2}$
$L=1.05\sqrt{\frac{I}{W}}$	$1.12\sqrt{\frac{I}{W}}$	$0.94\sqrt{\frac{I}{W}}$	$0.85\sqrt{\frac{I}{W}}$	$0.98\sqrt{\frac{I}{W}}$
	For directly computing I from $\frac{I}{c}$.			
$I=\frac{I}{c}\times 0.390L$	$\frac{I}{c}\times 0.370L$	$\frac{I}{c}\times 0.412L$	$\frac{I}{c}\times 0.405L$	$\frac{I}{c}\times 0.381L$
	For maximum safe fibre stress and deflection.			
$L=2.56c$	$2.70c$	$2.42c$	$2.47c$	$2.63c$
	Actual maximum deflection.			
$\Delta=\frac{WL^3}{33.3I}$	$\frac{WL^3}{37.8I}$	$\frac{WL^3}{26.7I}$	$\frac{WL^3}{22.2I}$	$\frac{WL^3}{28.9I}$

CASE 5A. JOIST SUPPORTED AT ENDS. LOAD UNIFORM

TABLE 8

General	Steel	Cast Iron	Fir, Wash.	Spruce
	For maximum safe fibre stress F.			
$\frac{I}{c}=\frac{wL^2e}{16000F}$	$\frac{wL^2e}{128000}$	$\frac{wL^2e}{24000}$	$\frac{wL^2e}{11200}$	$\frac{wL^2e}{7200}$
$w=\frac{I}{c}\times\frac{16000F}{L^2e}$	$\frac{I}{c}\times\frac{128000}{L^2e}$	$\frac{I}{c}\times\frac{24000}{L^2e}$	$\frac{I}{c}\times\frac{11200}{L^2e}$	$\frac{I}{c}\times\frac{7200}{L^2e}$
$e=\frac{I}{c}\times\frac{16000F}{wL^2}$	$\frac{I}{c}\times\frac{128000}{wL^2}$	$\frac{I}{c}\times\frac{24000}{wL^2}$	$\frac{I}{c}\times\frac{11200}{wL^2}$	$\frac{I}{c}\times\frac{7200}{wL^2}$
$L=\sqrt{\frac{I}{c}\times\frac{16000F}{we}}$	$357\sqrt{\frac{I}{wec}}$	$155\sqrt{\frac{I}{wec}}$	$106\sqrt{\frac{I}{wec}}$	$84.9\sqrt{\frac{I}{wec}}$
	For maximum safe deflection $\frac{L}{30}$.			
$I=\frac{wL^3e}{35.56E}$	$\frac{wL^3e}{515620}$	$\frac{wL^3e}{284480}$	$\frac{wL^3e}{24927}$	$\frac{wL^3e}{16000}$
$w=\frac{35.56EI}{L^3e}$	$\frac{515620I}{L^3e}$	$\frac{284480I}{L^3e}$	$\frac{24927I}{L^3e}$	$\frac{16000I}{L^3e}$
$e=\frac{35.56EI}{wL^3}$	$\frac{515620I}{wL^3}$	$\frac{284480I}{wL^3}$	$\frac{24927I}{wL^3}$	$\frac{16000I}{wL^3}$
$L=\sqrt[3]{\frac{35.56EI}{we}}$	$80.2\sqrt[3]{\frac{I}{we}}$	$65.8\sqrt[3]{\frac{I}{we}}$	$29.2\sqrt[3]{\frac{I}{we}}$	$25.2\sqrt[3]{\frac{I}{we}}$
	For directly computing I from $\frac{I}{c}$.			
$I=\frac{I}{c}\times\frac{450LF}{E}$	$\frac{I}{c}\times 0.248L$	$\frac{I}{c}\times 0.085L$	$\frac{I}{c}\times 0.450L$	$\frac{I}{c}\times 0.450L$
	For maximum safe fibre stress and deflection.			
$L=\frac{Ec}{450F}$	$4.02c$	$11.90c$	$2.22c$	$2.22c$
	Actual maximum deflection.			
$\Delta=\frac{wL^4e}{1067EI}$	$\frac{wL^4e}{15471500I}$	$\frac{wL^4e}{8536000I}$	$\frac{wL^4e}{746900I}$	$\frac{wL^4e}{480150I}$

CASE 5A. JOIST SUPPORTED AT ENDS. LOAD UNIFORM

TABLE 8

Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
For maximum safe fibre stress F.				
$\frac{I}{c}=\frac{wL^2e}{10400}$	$\frac{wL^2e}{11200}$	$\frac{wL^2e}{8800}$	$\frac{wL^2e}{7200}$	$\frac{wL^2e}{8800}$
$w=\frac{I}{c}\times\frac{10400}{L^2e}$	$\frac{I}{c}\times\frac{11200}{L^2e}$	$\frac{I}{c}\times\frac{8800}{L^2e}$	$\frac{I}{c}\times\frac{7200}{L^2e}$	$\frac{I}{c}\times\frac{8800}{L^2e}$
$e=\frac{I}{c}\times\frac{10400}{wL^2}$	$\frac{I}{c}\times\frac{11200}{wL^2}$	$\frac{I}{c}\times\frac{8800}{wL^2}$	$\frac{I}{c}\times\frac{7200}{wL^2}$	$\frac{I}{c}\times\frac{8800}{wL^2}$
$L=102\sqrt{\frac{I}{wec}}$	$106\sqrt{\frac{I}{wec}}$	$93.8\sqrt{\frac{I}{wec}}$	$84.9\sqrt{\frac{I}{wec}}$	$93.8\sqrt{\frac{I}{wec}}$
For maximum safe deflection $\frac{L}{30}$.				
$I=\frac{wL^3e}{26670}$	$\frac{wL^3e}{29606}$	$\frac{wL^3e}{21337}$	$\frac{wL^3e}{17780}$	$\frac{wL^3e}{23114}$
$w=\frac{26670I}{L^3e}$	$\frac{29606I}{L^3e}$	$\frac{21337I}{L^3e}$	$\frac{17780I}{L^3e}$	$\frac{23114I}{L^3e}$
$e=\frac{26670I}{wL^3}$	$\frac{29606I}{wL^3}$	$\frac{21337I}{wL^3}$	$\frac{17780I}{wL^3}$	$\frac{23114I}{wL^3}$
$L=29.9\sqrt[3]{\frac{I}{we}}$	$30.9\sqrt[3]{\frac{I}{we}}$	$27.7\sqrt[3]{\frac{I}{we}}$	$26.1\sqrt[3]{\frac{I}{we}}$	$28.5\sqrt[3]{\frac{I}{we}}$
For directly computing I from $\frac{I}{c}$.				
$I=\frac{I}{c}\times 0.390L$	$\frac{I}{c}\times 0.370L$	$\frac{I}{c}\times 0.412L$	$\frac{I}{c}\times 0.405L$	$\frac{I}{c}\times 0.381L$
For maximum safe fibre stress and deflection.				
$L=2.56c$	$2.70c$	$2.42c$	$2.47c$	$2.63c$
Actual maximum deflection.				
$\Delta=\frac{wL^4e}{800250I}$	$\frac{wL^4e}{906950I}$	$\frac{wL^4e}{640200I}$	$\frac{wL^4e}{533500I}$	$\frac{wL^4e}{640200I}$

CASE 5B. FLOORING SUPPORTED AT ENDS. LOAD UNIFORM

TABLE 9

General	Steel	Cast Iron	Fir, Wash.	Hemlock
For maximum safe fibre stress F.				
$t=\sqrt{\dfrac{wL^2}{2667F}}$	....	....	$\dfrac{L\sqrt{w}}{43.2}$	$\dfrac{L\sqrt{w}}{34.6}$
$w=\dfrac{2667Ft^2}{L^2}$	....	....	$\dfrac{1867t^2}{L^2}$	$\dfrac{1200t^2}{L^2}$
$L=\sqrt{\dfrac{2667Ft^2}{w}}$	....	....	$\dfrac{43.2t}{\sqrt{w}}$	$\dfrac{34.6t}{\sqrt{w}}$
For maximum safe deflection $\dfrac{L}{30}$.				
$t=\sqrt[3]{\dfrac{wL^3}{2.96E}}$	....	....	$\dfrac{L\sqrt[3]{w}}{14.4}$	$\dfrac{L\sqrt[3]{w}}{11.0}$
$w=\dfrac{2.96Et^3}{L^3}$	....	....	$\dfrac{2072t^3}{L^3}$	$\dfrac{1332t^3}{L^3}$
$L=\sqrt[3]{\dfrac{2.96Et^3}{w}}$	....	....	$\dfrac{14.4t}{\sqrt[3]{w}}$	$\dfrac{11.0t}{\sqrt[3]{w}}$
For maximum safe fibre stress and deflection.				
$L=\dfrac{Et}{902F}$	....	....	$1.06t$	$1.11t$
Actual maximum deflection.				
$\Delta=\dfrac{wL^4}{1067Et^3}$	....	....	$\dfrac{wL^4}{746900t^3}$	$\dfrac{wL^4}{480150t^3}$

CASE 5B. FLOORING SUPPORTED AT ENDS. LOAD UNIFORM

TABLE 9

	Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
	For maximum safe fibre stress F.				
$t=$	$\frac{L\sqrt{w}}{41.6}$	$\frac{L\sqrt{w}}{43.2}$	$\frac{L\sqrt{w}}{38.3}$	$\frac{L\sqrt{w}}{34.6}$	$\frac{L\sqrt{w}}{38.3}$
$w=$	$\frac{1734t^2}{L^2}$	$\frac{1867t^2}{L^2}$	$\frac{1467t^2}{L^2}$	$\frac{1200t^2}{L^2}$	$\frac{1467t^2}{L^2}$
$L=$	$\frac{41.6t}{\sqrt{w}}$	$\frac{43.2t}{\sqrt{w}}$	$\frac{38.3t}{\sqrt{w}}$	$\frac{34.6t}{\sqrt{w}}$	$\frac{38.3t}{\sqrt{w}}$
	For maximum safe deflection $\frac{L}{30}$.				
$t=$	$\frac{L\sqrt[3]{w}}{13.1}$	$\frac{L\sqrt[3]{w}}{13.6}$	$\frac{L\sqrt[3]{w}}{12.1}$	$\frac{L\sqrt[3]{w}}{11.4}$	$\frac{L\sqrt[3]{w}}{12.5}$
$w=$	$\frac{2220t^3}{L^3}$	$\frac{2516t^3}{L^3}$	$\frac{1776t^3}{L^3}$	$\frac{1480t^3}{L^3}$	$\frac{1924t^3}{L^3}$
$L=$	$\frac{13.1t}{\sqrt[3]{w}}$	$\frac{13.6t}{\sqrt[3]{w}}$	$\frac{12.1t}{\sqrt[3]{w}}$	$\frac{11.4t}{\sqrt[3]{w}}$	$\frac{12.5t}{\sqrt[3]{w}}$
	For maximum safe fibre stress and deflection.				
$L=$	$1.28t$	$1.35t$	$1.33t$	$1.24t$	$1.32t$
	Actual maximum deflection.				
$\Delta=$	$\frac{wL^4}{800250t^3}$	$\frac{wL^4}{906950t^3}$	$\frac{wL^4}{640200t^3}$	$\frac{wL^4}{533500t^3}$	$\frac{wL^4}{693550t^3}$

CASE 6. BEAM SUPPORTED AT ENDS. LOAD IRREGULAR

TABLE 10

General	Steel	Cast Iron	Fir, Wash.	Hemlock
	For maximum safe fibre stress F.			
$\frac{I}{c}=\frac{12M}{F}$	$1.50M$	$8.00M$	$17.15M$	$26.70M$
$M=\frac{I}{c}\times\frac{F}{12}$	$\frac{I}{c}\times 0.667$	$\frac{I}{c}\times 0.125$	$\frac{I}{c}\times 0.058$	$\frac{I}{c}\times 0.038$
	For maximum safe deflection $\frac{L}{30}$. Load at middle.			
$I=\frac{4320ML}{E}$	$0.298ML$	$0.539ML$	$6.17ML$	$9.61ML$
$M=\frac{EI}{4320L}$	$3.360\frac{I}{L}$	$1.850\frac{I}{L}$	$0.162\frac{I}{L}$	$0.104\frac{I}{L}$
$L=\frac{EI}{4320M}$	$3.360\frac{I}{M}$	$1.850\frac{I}{M}$	$0.162\frac{I}{M}$	$0.104\frac{I}{M}$
	For directly computing I from $\frac{I}{c}$.			
$I=\frac{I}{c}\times\frac{360LF}{E}$	$\frac{I}{c}\times 0.199L$	$\frac{I}{c}\times 0.068L$	$\frac{I}{c}\times 0.360L$	$\frac{I}{c}\times 0.360L$
	Actual maximum deflection.			
$\Delta=\frac{144ML^2}{EI}$	$\frac{ML^2}{100.7I}$	$\frac{ML^2}{55.6I}$	$\frac{ML^2}{4.86I}$	$\frac{ML^2}{3.13I}$
	For maximum safe deflection. Load uniform.			
$I=\frac{5400ML}{E}$	$0.372ML$	$0.675ML$	$7.72ML$	$12.00ML$
$M=\frac{EI}{5400L}$	$2.68\frac{I}{L}$	$1.48\frac{I}{L}$	$0.130\frac{I}{L}$	$0.083\frac{I}{L}$
$L=\frac{EI}{5400M}$	$2.68\frac{I}{M}$	$1.48\frac{I}{M}$	$0.130\frac{I}{M}$	$0.083\frac{I}{M}$
	For directly computing I from $\frac{I}{c}$.			
$I=\frac{I}{c}\times\frac{450LF}{E}$	$\frac{I}{c}\times 0.248L$	$\frac{I}{c}\times 0.085L$	$\frac{I}{c}\times 0.450L$	$\frac{I}{c}\times 0.450L$
	Actual maximum deflection.			
$\Delta=\frac{180ML^2}{EI}$	$\frac{ML^2}{80.7I}$	$\frac{ML^2}{44.4I}$	$\frac{ML^2}{3.89I}$	$\frac{ML^2}{3.12I}$

CASE 6. BEAM SUPPORTED AT ENDS. LOAD IRREGULAR

TABLE 10

	Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
	For maximum safe fibre stress F.				
$\frac{I}{c}=$	$18.48M$	$17.15M$	$21.84M$	$26.70M$	$21.84M$
$M=$	$0.054\frac{I}{c}$	$0.058\frac{I}{c}$	$0.046\frac{I}{c}$	$0.038\frac{I}{c}$	$0.046\frac{I}{c}$
	For maximum safe deflection $\frac{L}{30}$. Load at middle.				
$I=$	$5.77ML$	$5.08ML$	$7.21ML$	$8.64ML$	$6.65ML$
$M=$	$0.174\frac{I}{L}$	$0.197\frac{I}{L}$	$0.139\frac{I}{L}$	$0.116\frac{I}{L}$	$0.151\frac{I}{L}$
$L=$	$0.174\frac{I}{M}$	$0.197\frac{I}{M}$	$0.139\frac{I}{M}$	$0.116\frac{I}{M}$	$0.151\frac{I}{M}$
	For directly computing I from $\frac{I}{c}$.				
$I=$	$\frac{I}{c}\times 0.312L$	$\frac{I}{c}\times 0.297L$	$\frac{I}{c}\times 0.330L$	$\frac{I}{c}\times 0.324L$	$\frac{I}{c}\times 0.330L$
	Actual maximum deflection.				
$\Delta=$	$\frac{ML^2}{5.21I}$	$\frac{ML^2}{5.90I}$	$\frac{ML^2}{4.17I}$	$\frac{ML^2}{3.47I}$	$\frac{ML^2}{4.52I}$
	For maximum safe deflection. Load uniform.				
$I=$	$7.20ML$	$6.35ML$	$9.00ML$	$10.80ML$	$8.32ML$
$M=$	$0.139\frac{I}{L}$	$0.158\frac{I}{L}$	$0.111\frac{I}{L}$	$0.093\frac{I}{L}$	$0.120\frac{I}{L}$
$L=$	$0.139\frac{I}{M}$	$0.158\frac{I}{M}$	$0.111\frac{I}{M}$	$0.093\frac{I}{M}$	$0.120\frac{I}{M}$
	For directly computing I from $\frac{I}{c}$.				
$I=$	$\frac{I}{c}\times 0.390L$	$\frac{I}{c}\times 0.371L$	$\frac{I}{c}\times 0.413L$	$\frac{I}{c}\times 0.405L$	$\frac{I}{c}\times 0.382L$
	Actual maximum deflection.				
$\Delta=$	$\frac{ML^2}{4.17I}$	$\frac{ML^2}{4.72I}$	$\frac{ML^2}{3.33I}$	$\frac{ML^2}{2.78I}$	$\frac{ML^2}{3.61I}$

CASE 7. BEAM FIXED AND SUPPORTED AT ENDS. LOAD AT MIDDLE. TABLE 11

General	Steel	Cast Iron	Fir, Wash.	Hemlock
For maximum safe fibre stress F.				
$\frac{I}{c}=\frac{2.25WL}{F}$	$0.281WL$	$1.50WL$	$3.20WL$	$4.98WL$
$W=\frac{I}{c}\times\frac{F}{2.25L}$	$\frac{I}{c}\times\frac{3.560}{L}$	$\frac{I}{c}\times\frac{0.667}{L}$	$\frac{I}{c}\times\frac{0.311}{L}$	$\frac{I}{c}\times\frac{0.200}{L}$
$L=\frac{I}{c}\times\frac{F}{2.25L}$	$\frac{I}{c}\times\frac{3.560}{W}$	$\frac{I}{c}\times\frac{0.667}{W}$	$\frac{I}{c}\times\frac{0.311}{W}$	$\frac{I}{c}\times\frac{0.200}{W}$
For maximum safe deflection $\frac{L}{30}$.				
$I=\frac{472.5WL^2}{E}$	$0.0328WL^2$	$0.0591WL^2$	$0.675WL^2$	$1.050WL^2$
$W=\frac{EI}{472.5L^2}$	$3.070\frac{I}{L^2}$	$1.694\frac{I}{L^2}$	$1.482\frac{I}{L^2}$	$0.953\frac{I}{L^2}$
$L=\sqrt{\frac{EI}{472.5W}}$	$1.75\sqrt{\frac{I}{W}}$	$1.30\sqrt{\frac{I}{W}}$	$1.22\sqrt{\frac{I}{W}}$	$0.98\sqrt{\frac{I}{W}}$
For directly computing I from $\frac{I}{c}$.				
$I=\frac{I}{c}\times 210LF$	$\frac{I}{c}\times 0.160L$	$\frac{I}{c}\times 0.394L$	$\frac{I}{c}\times 0.210L$	$\frac{I}{c}\times 0.210L$
For maximum safe fibre stress and deflection.				
$L=\frac{Ec}{210F}$	$8.66c$	$25.40c$	$4.77c$	$4.77c$
Actual maximum deflection.				
$\Delta=\frac{15.75WL^3}{EI}$	$\frac{WL^3}{920.7I}$	$\frac{WL^3}{508.0I}$	$\frac{WL^3}{44.5I}$	$\frac{WL^3}{28.6I}$

CASE 7. BEAM FIXED AND SUPPORTED AT ENDS. LOAD AT MIDDLE. TABLE 11

Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
		For maximum safe fibre stress F.		
$\frac{I}{c}=3.45WL$	$3.20WL$	$4.08WL$	$4.98WL$	$4.08WL$
$W=\frac{I}{c}\times\frac{0.289}{L}$	$\frac{I}{c}\times\frac{0.311}{L}$	$\frac{I}{c}\times\frac{0.245}{L}$	$\frac{I}{c}\times\frac{0.200}{L}$	$\frac{I}{c}\times\frac{0.245}{L}$
$L=\frac{I}{c}\times\frac{0.289}{W}$	$\frac{I}{c}\times\frac{0.311}{W}$	$\frac{I}{c}\times\frac{0.245}{W}$	$\frac{I}{c}\times\frac{0.200}{W}$	$\frac{I}{c}\times\frac{0.245}{W}$
		For maximum safe deflection $\frac{L}{30}$.		
$I=0.630WL^2$	$0.556WL^2$	$0.788WL^2$	$0.946WL^2$	$0.728\,WL^2$
$W=1.588\frac{I}{L^2}$	$1.800\frac{I}{L^2}$	$1.270\frac{I}{L^2}$	$1.058\frac{I}{L^2}$	$1.376\frac{I}{L^2}$
$L=1.26\sqrt{\frac{I}{W}}$	$1.34\sqrt{\frac{I}{W}}$	$1.13\sqrt{\frac{I}{W}}$	$1.03\sqrt{\frac{I}{W}}$	$1.17\sqrt{\frac{I}{W}}$
		For directly computing I from $\frac{I}{c}$.		
$I=\frac{I}{c}\times0.191L$	$\frac{I}{c}\times0.181L$	$\frac{I}{c}\times0.203L$	$\frac{I}{c}\times0.198L$	$\frac{I}{c}\times0.186L$
		For maximum safe fibre stress and deflection.		
$L=5.50c$	$5.79c$	$5.20c$	$5.30c$	$5.63c$
		Actual maximum deflection.		
$\Delta=\frac{WL^3}{47.6I}$	$\frac{WL^3}{53.0I}$	$\frac{WL^3}{37.1I}$	$\frac{WL^3}{31.8I}$	$\frac{WL^3}{41.3I}$

CASE 8. BEAM FIXED AND SUPPORTED AT ENDS. LOAD UNIFORM. TABLE 12

General	Steel	Cast Iron	Fir, Wash.	Hemlock
	For maximum safe fibre stress F.			
$\frac{I}{c}=\frac{1.5WL}{F}$	$0.187WL$	$1.000WL$	$2.14WL$	$3.33WL$
$W=\frac{I}{c}\times\frac{0.667F}{L}$	$\frac{I}{c}\times\frac{5.33}{L}$	$\frac{I}{c}\times\frac{1.00}{L}$	$\frac{I}{c}\times\frac{0.467}{L}$	$\frac{I}{c}\times\frac{0.300}{L}$
$L=\frac{I}{c}\times\frac{0.667F}{W}$	$\frac{I}{c}\times\frac{5.33}{W}$	$\frac{I'}{c}\times\frac{1.00}{W}$	$\frac{I}{c}\times\frac{0.467}{W}$	$\frac{I}{c}\times\frac{0.300}{W}$
	For maximum safe deflection $\frac{L}{30}$.			
$I=\frac{270WL^2}{E}$	$0.0186WL^2$	$0.0338WL^2$	$0.386WL^2$	$0.600WL^2$
$W=\frac{EI}{270L^2}$	$\frac{53.80I}{L^2}$	$\frac{29.65I}{L^2}$	$\frac{2.59I}{L^2}$	$\frac{1.67I}{L^2}$
$L=\sqrt{\frac{EI}{270W}}$	$7.33\sqrt{\frac{I}{W}}$	$5.44\sqrt{\frac{I}{W}}$	$1.61\sqrt{\frac{I}{W}}$	$1.29\sqrt{\frac{I}{W}}$
	For directly computing I from $\frac{I}{c}$.			
$I=\frac{I}{c}\times\frac{180LF}{E}$	$\frac{I}{c}\times 0.099L$	$\frac{I}{c}\times 0.034L$	$\frac{I}{c}\times 0.180L$	$\frac{I}{c}\times 0.180L$
	For maximum safe fibre stress and deflection.			
$L=\frac{Ec}{180F}$	$10.1c$	$29.7c$	$5.56c$	$5.56c$
	Actual maximum deflection.			
$\Delta=\frac{9WL^3}{EI}$	$\frac{WL^3}{1612I}$	$\frac{WL^3}{885I}$	$\frac{WL^3}{77.8I}$	$\frac{WL^3}{50.0I}$

CASE 8. BEAM FIXED AND SUPPORTED AT ENDS. LOAD UNIFORM. TABLE 12

Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
For maximum fibre stress F.				
$\frac{I}{c}=2.31WL$	$2.14WL$	$2.72WL$	$3.33WL$	$2.72WL$
$W=\frac{I}{c}\times\frac{0.438}{L}$	$\frac{I}{c}\times\frac{0.467}{L}$	$\frac{I}{c}\times\frac{0.367}{L}$	$\frac{I}{c}\times\frac{0.300}{L}$	$\frac{I}{c}\times\frac{0.367}{L}$
$L=\frac{I}{c}\times\frac{0.438}{W}$	$\frac{I}{c}\times\frac{0.467}{W}$	$\frac{I}{c}\times\frac{0.367}{W}$	$\frac{I}{c}\times\frac{0.300}{W}$	$\frac{I}{c}\times\frac{0.367}{W}$
For maximum safe deflection $\frac{L}{30}$.				
$I=0.360WL^2$	$0.318WL^2$	$0.450WL^2$	$0.540WL^2$	$0.416WL^2$
$W=\frac{2.78I}{L^2}$	$\frac{3.15I}{L^2}$	$\frac{2.22I}{L^2}$	$\frac{1.85I}{L^2}$	$\frac{2.41I}{L^2}$
$L=1.67\sqrt{\frac{I}{W}}$	$1.77\sqrt{\frac{I}{W}}$	$1.49\sqrt{\frac{I}{W}}$	$1.36\sqrt{\frac{I}{W}}$	$1.55\sqrt{\frac{I}{W}}$
For directly computing I from $\frac{I}{c}$.				
$I=\frac{I}{c}\times 0.156L$	$\frac{I}{c}\times 0.148L$	$\frac{I}{c}\times 0.165L$	$\frac{I}{c}\times 0.162L$	$\frac{I}{c}\times 0.152L$
For maximum safe fibre stress and deflection.				
$L=6.42c$	$6.75c$	$6.07c$	$6.18c$	$6.57c$
Actual maximum deflection.				
$\Delta=\frac{WL^3}{83.3I}$	$\frac{WL^3}{94.4I}$	$\frac{WL^3}{66.7I}$	$\frac{WL^3}{55.6I}$	$\frac{WL^3}{72.2I}$

CASE 8A. JOIST WITH ENDS FIXED AND SUPPORTED. LOAD UNIFORM. TABLE 13

General	Steel	Cast Iron	Fir, Wash.	Hemlock
	For maximum safe fibre stress F.			
$\frac{I}{c}=\frac{wL^2e}{16000F}$	$\frac{wL^2e}{128000}$	$\frac{wL^2e}{24000}$	$\frac{wL^2e}{11200}$	$\frac{wL^2e}{7200}$
$w=\frac{I}{c}\times\frac{16000F}{L^2e}$	$\frac{I}{c}\times\frac{128000}{L^2e}$	$\frac{I}{c}\times\frac{24000}{L^2e}$	$\frac{I}{c}\times\frac{11200}{L^2e}$	$\frac{I}{c}\times\frac{7200}{L^2e}$
$e=\frac{I}{c}\times\frac{16000F}{wL^2}$	$\frac{I}{c}\times\frac{128000}{wL^2}$	$\frac{I}{c}\times\frac{24000}{wL^2}$	$\frac{I}{c}\times\frac{11200}{wL^2}$	$\frac{I}{c}\times\frac{7200}{wL^2}$
$L=\sqrt{\frac{I}{c}\times\frac{16000F}{we}}$	$358\sqrt{\frac{I}{wec}}$	$155\sqrt{\frac{I}{wec}}$	$106\sqrt{\frac{I}{wec}}$	$84.9\sqrt{\frac{I}{wec}}$
	For maximum safe deflection $\frac{L}{30}$.			
$I=\frac{wL^3e}{88.89E}$	$\frac{wL^3e}{1288905}$	$\frac{wL^3e}{711120}$	$\frac{wL^3e}{62223}$	$\frac{wL^3e}{40000}$
$w=\frac{88.89EI}{L^3e}$	$\frac{1288905I}{L^3e}$	$\frac{711120I}{L^3e}$	$\frac{62223I}{L^3e}$	$\frac{40000I}{L^3e}$
$e=\frac{88.89EI}{wL^3}$	$\frac{1288905I}{wL^3}$	$\frac{711120I}{wL^3}$	$\frac{62223I}{wL^3}$	$\frac{40000I}{wL^3}$
$L=\sqrt[3]{\frac{88.89EI}{we}}$	$108.8\sqrt[3]{\frac{I}{we}}$	$89.3\sqrt[3]{\frac{I}{we}}$	$39.6\sqrt[3]{\frac{I}{we}}$	$34.2\sqrt[3]{\frac{I}{we}}$
	For directly computing I from $\frac{I}{c}$.			
$I=\frac{I}{c}\times\frac{180LF}{E}$	$\frac{I}{c}\times 0.099L$	$\frac{I}{c}\times 0.034L$	$\frac{I}{c}\times 0.180L$	$\frac{I}{c}\times 0.180L$
	For maximum safe fibre stress and deflection.			
$L=\frac{Ec}{180F}$	$10.1c$	$29.7c$	$5.56c$	$5.56c$
	Actual maximum deflection.			
$\Delta=\frac{wL^4e}{2667EI}$	$\frac{wL^4e}{38671500I}$	$\frac{wL^4e}{21336000I}$	$\frac{wL^4e}{1866900I}$	$\frac{wL^4e}{1200150I}$

CASE 8A. JOIST WITH ENDS FIXED AND SUPPORTED. LOAD UNIFORM. TABLE 13

	Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
		For maximum safe fibre stress F.			
$\frac{I}{c}=$	$\frac{wL^2e}{10400}$	$\frac{wL^2e}{11200}$	$\frac{wL^2e}{8800}$	$\frac{wL^2e}{7200}$	$\frac{wL^2e}{8800}$
$w=$	$\frac{I}{c}\times\frac{10400}{L^2e}$	$\frac{I}{c}\times\frac{11200}{L^2e}$	$\frac{I}{c}\times\frac{8800}{L^2e}$	$\frac{I}{c}\times\frac{7200}{L^2e}$	$\frac{I}{c}\times\frac{8800}{L^2e}$
$e=$	$\frac{I}{c}\times\frac{10400}{wL^2}$	$\frac{I}{c}\times\frac{11200}{wL^2}$	$\frac{I}{c}\times\frac{8800}{wL^2}$	$\frac{I}{c}\times\frac{7200}{wL^2}$	$\frac{I}{c}\times\frac{8800}{wL^2}$
$L=$	$102\sqrt{\frac{I}{wec}}$	$106\sqrt{\frac{I}{wec}}$	$93.8\sqrt{\frac{I}{wec}}$	$84.9\sqrt{\frac{I}{wec}}$	$93.8\sqrt{\frac{I}{wec}}$
		For maximum safe deflection $\frac{L}{30}$.			
$I=$	$\frac{wL^3e}{66668}$	$\frac{wL^3e}{75557}$	$\frac{wL^3e}{53334}$	$\frac{wL^3e}{44445}$	$\frac{wL^3e}{57779}$
$w=$	$\frac{66668I}{L^3e}$	$\frac{75557I}{L^3e}$	$\frac{53334I}{L^3e}$	$\frac{44445I}{L^3e}$	$\frac{57779I}{L^3e}$
$e=$	$\frac{66668I}{wL^3}$	$\frac{75557I}{wL^3}$	$\frac{53334I}{wL^3}$	$\frac{44445I}{wL^3}$	$\frac{57779I}{wL^3}$
$L=$	$40.5\sqrt[3]{\frac{I}{we}}$	$42.3\sqrt[3]{\frac{I}{we}}$	$37.6\sqrt[3]{\frac{I}{we}}$	$35.4\sqrt[3]{\frac{I}{we}}$	$38.7\sqrt[3]{\frac{I}{we}}$
		For directly computing I from $\frac{I}{c}$.			
$I=$	$\frac{I}{c}\times0.156L$	$\frac{I}{c}\times0.148L$	$\frac{I}{c}\times0.165L$	$\frac{I}{c}\times0.162L$	$\frac{I}{c}\times0.152L$
		For maximum safe fibre stress and deflection.			
$L=$	$6.42c$	$6.75c$	$6.07c$	$6.18c$	$6.58c$
		Actual maximum deflection.			
$\Delta=$	$\frac{wL^4e}{2000250I}$	$\frac{wL^4e}{2266950I}$	$\frac{wL^4e}{1600200I}$	$\frac{wL^4e}{1333500I}$	$\frac{wL^4e}{1733550I}$

CASE 8B. FLOORING WITH ENDS FIXED AND SUPPORTED LOAD UNIFORM. TABLE 14

General	Steel	Cast Iron	Fir, Wash.	Hemlock
For maximum safe fibre stress F.				
$t=\sqrt{\dfrac{wL^2}{2667F}}$	....	....	$\dfrac{k\sqrt{w}}{43.2}$	$\dfrac{k\sqrt{w}}{34.6}$
$w=\dfrac{2667F}{L^2}$	....	....	$\dfrac{1867t^2}{L^2}$	$\dfrac{1200t^2}{L^2}$
$L=\sqrt{\dfrac{2667F}{w}}$	....	....	$\dfrac{43.2t}{\sqrt{w}}$	$\dfrac{34.6t}{\sqrt{w}}$
For maximum safe deflection $\dfrac{L}{30}$.				
$t=\sqrt[3]{\dfrac{wL^3}{7.41E}}$	....	....	$\dfrac{L\sqrt[3]{w}}{17.3}$	$\dfrac{L\sqrt[3]{w}}{15.0}$
$w=\dfrac{7.41Et^3}{L^3}$	....	....	$\dfrac{5187t^3}{L^3}$	$\dfrac{3335t^3}{L^3}$
$L=\sqrt[3]{\dfrac{7.41Et^3}{w}}$	....	....	$\dfrac{17.3t}{\sqrt[3]{w}}$	$\dfrac{15.0}{\sqrt[3]{w}}$
For maximum safe fibre stress and deflection.				
$L=\dfrac{Et}{360F}$	....	....	$2.78t$	$2.78t$
Actual maximum deflection.				
$\Delta=\dfrac{wL^4}{222Et^3}$	....	....	$\dfrac{wL^4}{155400t^3}$	$\dfrac{wL^4}{99900t^3}$

CASE 8B. FLOORING WITH ENDS FIXED AND SUPPORTED LOAD UNIFORM. TABLE 14

	Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
		For maximum safe fibre stress F.			
$t=$	$\frac{L\sqrt{w}}{41.6}$	$\frac{L\sqrt{w}}{43.2}$	$\frac{L\sqrt{w}}{38.3}$	$\frac{L\sqrt{w}}{34.6}$	$\frac{L\sqrt{w}}{38.3}$
$w=$	$\frac{1734t^2}{L^2}$	$\frac{1867t^2}{L^2}$	$\frac{1467t^2}{L^2}$	$\frac{1200t^2}{L^2}$	$\frac{1467t^2}{L^2}$
$L=$	$\frac{41.6t}{\sqrt{w}}$	$\frac{43.2t}{\sqrt{w}}$	$\frac{38.3t}{\sqrt{w}}$	$\frac{34.6t}{\sqrt{w}}$	$\frac{38.3t}{\sqrt{w}}$
		For maximum safe deflection $\frac{L}{30}$.			
$t=$	$\frac{L\sqrt[3]{w}}{17.7}$	$\frac{L\sqrt[3]{w}}{18.5}$	$\frac{L\sqrt[3]{w}}{16.4}$	$\frac{L\sqrt[3]{w}}{15.5}$	$\frac{L\sqrt[3]{w}}{16.9}$
$w=$	$5558\frac{t^3}{L^3}$	$6299\frac{t^3}{L^3}$	$4446\frac{t^3}{L^3}$	$3705\frac{t^3}{L^3}$	$4817\frac{t^3}{L^3}$
$L=$	$\frac{17.7t}{\sqrt[3]{w}}$	$\frac{18.5t}{\sqrt[3]{w}}$	$\frac{16.4t}{\sqrt[3]{w}}$	$\frac{15.5t}{\sqrt[3]{w}}$	$\frac{16.9t}{\sqrt[3]{w}}$
		For maximum safe fibre stress and deflection.			
$L=$	$3.21t$	$3.38t$	$3.04t$	$3.09t$	$3.04t$
		Actual maximum deflection.			
$\Delta=$	$\frac{wL^4}{166500t^3}$	$\frac{wL^4}{188700t^3}$	$\frac{wL^4}{133200t^3}$	$\frac{wL^4}{111000t^3}$	$\frac{wL^4}{144300t^3}$

CASE 9. BEAM FIXED AT ENDS. LOAD AT MIDDLE

TABLE 15

General.	Steel.	Cast Iron	Fir, Wash.	Hemlock
	For maximum safe fibre stress F.			
$\frac{I}{c}=\frac{1.5WL}{F}$	$0.187WL$	$1.00WL$	$2.14WL$	$3.33WL$
$W=\frac{I}{c}\times\frac{0.667F}{L}$	$\frac{I}{c}\times\frac{5.325}{L}$	$\frac{I}{c}\times\frac{1.000}{L}$	$\frac{I}{c}\times\frac{0.467}{L}$	$\frac{I}{c}\times\frac{0.300}{L}$
$L=\frac{I}{c}\times\frac{0.667F}{W}$	$\frac{I}{c}\times\frac{5.325}{W}$	$\frac{I}{c}\times\frac{1.000}{W}$	$\frac{I}{c}\times\frac{0.467}{W}$	$\frac{I}{c}\times\frac{0.300}{W}$
	For maximum safe deflection $\frac{L}{30}$.			
$I=\frac{270WL^2}{E}$	$0.0186WL^2$	$0.0338WL^2$	$0.386WL^2$	$0.600WL^2$
$W=\frac{EI}{270L^2}$	$\frac{53.7I}{L^2}$	$\frac{29.6I}{L^2}$	$\frac{2.59I}{L^2}$	$\frac{1.67I}{L^2}$
$L=\sqrt{\frac{EI}{270W}}$	$7.38\sqrt{\frac{I}{W}}$	$5.44\sqrt{\frac{I}{W}}$	$1.61\sqrt{\frac{I}{W}}$	$1.29\sqrt{\frac{I}{W}}$
	For directly computing I from $\frac{I}{c}$.			
$I=\frac{I}{c}\times\frac{180LF}{E}$	$\frac{I}{c}\times 0.099L$	$\frac{I}{c}\times 0.034L$	$\frac{I}{c}\times 0.180L$	$\frac{I}{c}\times 0.180L$
	For maximum safe fibre stress and deflection.			
$L=\frac{Ec}{180F}$	$10.1c$	$29.7c$	$5.56c$	$5.56c$
	Actual maximum deflection.			
$\Delta=\frac{9WL^3}{EI}$	$\frac{WL^3}{1611I}$	$\frac{WL^3}{888.7I}$	$\frac{WL^3}{77.8I}$	$\frac{WL^3}{50.0I}$

CASE 9. BEAM FIXED AT ENDS. LOAD AT MIDDLE
TABLE 15

Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
For maximum fibre stress F.				
$\frac{I}{c}=2.31WL$	$2.14WL$	$2.72WL$	$3.33WL$	$2.72WL$
$W=\frac{I}{c}\times\frac{0.433}{L}$	$\frac{I}{c}\times\frac{0.467}{L}$	$\frac{I}{c}\times\frac{0.367}{L}$	$\frac{I}{c}\times\frac{0.300}{L}$	$\frac{I}{c}\times\frac{0.367}{L}$
$L=\frac{I}{c}\times\frac{0.433}{W}$	$\frac{I}{c}\times\frac{0.467}{W}$	$\frac{I}{c}\times\frac{0.367}{W}$	$\frac{I}{c}\times\frac{0.300}{W}$	$\frac{I}{c}\times\frac{0.367}{W}$
For maximum safe deflection $\frac{L}{30}$.				
$I=0.360WL^2$	$0.318WL^2$	$0.450WL^2$	$0.540WL^2$	$0.416WL^2$
$W=\frac{2.78I}{L^2}$	$\frac{3.15I}{L^2}$	$\frac{2.22I}{L^2}$	$\frac{1.85I}{L^2}$	$\frac{2.41I}{L^2}$
$L=1.67\sqrt{\frac{I}{W}}$	$1.78\sqrt{\frac{I}{W}}$	$1.49\sqrt{\frac{I}{W}}$	$1.36\sqrt{\frac{I}{W}}$	$1.55\sqrt{\frac{I}{W}}$
For directly computing I from $\frac{I}{c}$.				
$I=\frac{I}{c}\times0.156L$	$\frac{I}{c}\times0.148L$	$\frac{I}{c}\times0.165L$	$\frac{I}{c}\times0.162L$	$\frac{I}{c}\times0.152L$
For maximum safe fibre stress and deflection.				
$L=6.42c$	$6.75c$	$6.07c$	$6.18c$	$6.58c$
Actual maximum deflection.				
$\Delta=\frac{WL^3}{83.3I}$	$\frac{WL^3}{94.5I}$	$\frac{WL^3}{66.7I}$	$\frac{WL^3}{55.6I}$	$\frac{WL^3}{72.2I}$

CASE 10. BEAM FIXED AT ENDS. LOAD UNIFORM

TABLE 16

General	Steel	Cast Iron	Fir, Wash.	Hemlock
	For maximum safe fibre stress F.			
$\frac{I}{c}=\frac{WL}{F}$	$0.125WL$	$0.667WL$	$1.43WL$	$2.22WL$
$W=\frac{I}{c}\times\frac{F}{L}$	$\frac{I}{c}\times\frac{8.00}{L}$	$\frac{I}{c}\times\frac{1.50}{L}$	$\frac{I}{c}\times\frac{0.70}{L}$	$\frac{I}{c}\times\frac{0.45}{L}$
$L=\frac{I}{c}\times\frac{F}{W}$	$\frac{I}{c}\times\frac{8.00}{W}$	$\frac{I}{c}\times\frac{1.50}{W}$	$\frac{I}{c}\times\frac{0.70}{W}$	$\frac{I}{c}\times\frac{0.45}{W}$
	For maximum safe deflection $\frac{L}{30}$.			
$I=\frac{135WL^2}{E}$	$0.0093WL^2$	$0.0169WL^2$	$0.193WL^2$	$0.299WL^2$
$W=\frac{EI}{135L^2}$	$107.4\frac{I}{L^2}$	$59.3\frac{I}{L^2}$	$5.18\frac{I}{L^2}$	$3.33\frac{I}{L^2}$
$L=\sqrt{\frac{EI}{135W}}$	$10.35\sqrt{\frac{I}{W}}$	$7.70\sqrt{\frac{I}{W}}$	$2.28\sqrt{\frac{I}{W}}$	$1.83\sqrt{\frac{I}{W}}$
	For directly computing I from $\frac{I}{c}$.			
$I=\frac{I}{c}\times\frac{135LF}{E}$	$\frac{I}{c}\times 0.075L$	$\frac{I}{c}\times 0.025L$	$\frac{I}{c}\times 0.135L$	$\frac{I}{c}\times 0.135L$
	For maximum safe fibre stress and deflection.			
$L=\frac{Ec}{135F}$	$13.43c$	$39.50c$	$7.40c$	$7.40c$
	Actual maximum deflection.			
$\Delta=\frac{4.5WL^3}{EI}$	$\frac{WL^3}{3225I}$	$\frac{WL^3}{1778I}$	$\frac{WL^3}{155.5I}$	$\frac{WL^3}{100.0I}$

CASE 10. BEAM FIXED AT ENDS. LOAD UNIFORM

TABLE 16

	Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
	For maximum safe fibre stress F.				
	$\frac{I}{c}=1.54WL$	$1.43WL$	$1.82WL$	$2.22WL$	$1.82WL$
	$W=\frac{I}{c}\times\frac{0.65}{L}$	$\frac{I}{c}\times\frac{0.70}{L}$	$\frac{I}{c}\times\frac{0.55}{L}$	$\frac{I}{c}\times\frac{0.45}{L}$	$\frac{I}{c}\times\frac{0.55}{L}$
	$L=\frac{I}{c}\times\frac{0.65}{W}$	$\frac{I}{c}\times\frac{0.70}{W}$	$\frac{I}{c}\times\frac{0.55}{W}$	$\frac{I}{c}\times\frac{0.45}{W}$	$\frac{I}{c}\times\frac{0.55}{W}$
	For maximum safe deflection $\frac{L}{30}$.				
	$I=0.180WL^2$	$0.159WL^2$	$0.224WL^2$	$0.269WL^2$	$0.208WL^2$
	$W=5.56\frac{I}{L^2}$	$6.30\frac{I}{L^2}$	$4.44\frac{I}{L^2}$	$3.70\frac{I}{L^2}$	$4.82\frac{I}{L^2}$
	$L=2.36\sqrt{\frac{I}{W}}$	$2.51\sqrt{\frac{I}{W}}$	$2.11\sqrt{\frac{I}{W}}$	$1.93\sqrt{\frac{I}{W}}$	$2.20\sqrt{\frac{I}{W}}$
	For directly computing I from $\frac{I}{c}$.				
	$I=\frac{I}{c}\times 0.117L$	$\frac{I}{c}\times 0.111L$	$\frac{I}{c}\times 0.124L$	$\frac{I}{c}\times 0.122L$	$\frac{I}{c}\times 0.114L$
	For maximum safe fibre stress and deflection.				
	$L=8.55c$	$8.98c$	$8.10c$	$8.24c$	$8.76c$
	Actual maximum deflection.				
	$\Delta=\frac{WL^3}{186.7I}$	$\frac{WL^3}{189.0I}$	$\frac{WL^3}{133.3I}$	$\frac{WL^3}{111.0I}$	$\frac{WL^3}{144.5I}$

CASE 10A. JOIST WITH ENDS FIXED. LOAD UNIFORM

TABLE 17

General	Steel	Cast Iron	Fir, Wash.	Hemlock
For maximum safe fibre stress F.				
$\frac{I}{c}=\frac{wL^2e}{24000F}$	$\frac{wL^2e}{192000}$	$\frac{wL^2e}{36000}$	$\frac{wL^2e}{16800}$	$\frac{wL^2e}{10800}$
$w=\frac{I}{c}\times\frac{24000F}{L^2e}$	$\frac{I}{c}\times\frac{192000}{L^2e}$	$\frac{I}{c}\times\frac{36000}{L^2e}$	$\frac{I}{c}\times\frac{16800}{L^2e}$	$\frac{I}{c}\times\frac{10800}{L^2e}$
$e=\frac{I}{c}\times\frac{24000F}{wL^2}$	$\frac{I}{c}\times\frac{192000}{wL^2}$	$\frac{I}{c}\times\frac{36000}{wL^2}$	$\frac{I}{c}\times\frac{16800}{wL^2}$	$\frac{I}{c}\times\frac{10800}{wL^2}$
$L=\sqrt{\frac{I}{c}\times\frac{24000F}{we}}$	$\sqrt{\frac{I}{c}\times\frac{192000}{we}}$	$\sqrt{\frac{I}{c}\times\frac{36000}{we}}$	$\sqrt{\frac{I}{c}\times\frac{16800}{we}}$	
For maximum safe deflection $\frac{L}{30}$.				
$I=\frac{wL^3e}{177.8E}$	$\frac{wL^3e}{2578100}$	$\frac{wL^3e}{1422400}$	$\frac{wL^3e}{124460}$	$\frac{wL^3e}{80010}$
$w=\frac{177.8EI}{L^3e}$	$\frac{2578100I}{L^3e}$	$\frac{1422400I}{L^3e}$	$\frac{124460I}{L^3e}$	$\frac{80010I}{L^3e}$
$e=\frac{177.8EI}{wL^3}$	$\frac{2578100I}{wL^3}$	$\frac{1422400I}{wL^3}$	$\frac{124460I}{wL^3}$	$\frac{80010I}{wL^3}$
$L=\sqrt[3]{\frac{177.8EI}{we}}$	$137.1\sqrt[3]{\frac{I}{we}}$	$112.5\sqrt[3]{\frac{I}{we}}$	$49.9\sqrt[3]{\frac{I}{we}}$	$43.1\sqrt[3]{\frac{I}{we}}$
For directly computing I from $\frac{I}{c}$.				
$I=\frac{I}{c}\times\frac{135LF}{E}$	$\frac{I}{c}\times 0.0745L$	$\frac{I}{c}\times 0.0253L$	$\frac{I}{c}\times 0.135$	$\frac{I}{c}\times 0.135L$
For maximum safe fibre stress and deflection.				
$L=\frac{ec}{135F}$	$13.43c$	$39.50c$	$7.40c$	$7.40c$
Actual maximum deflection.				
$\Delta=\frac{wL^4e}{5333EI}$	$\frac{wL^4e}{77328500I}$	$\frac{wL^4e}{42664000I}$	$\frac{wL^4e}{3733100I}$	$\frac{wL^4e}{2399850I}$

CASE 10A. JOIST WITH ENDS FIXED. LOAD UNIFORM

TABLE 17

Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
For maximum safe fibre stress F.				
$\frac{I}{c}=\frac{wL^2e}{15600}$	$\frac{wL^2e}{16800}$	$\frac{wL^2e}{13200}$	$\frac{wL^2e}{10800}$	$\frac{wL^2e}{13200}$
$w=\frac{I}{c}\times\frac{15600}{L^2e}$	$\frac{I}{c}\times\frac{16800}{L^2e}$	$\frac{I}{c}\times\frac{13200}{L^2e}$	$\frac{I}{c}\times\frac{10800}{L^2e}$	$\frac{I}{c}\times\frac{13200}{L^2e}$
$e=\frac{I}{c}\times\frac{15600}{wL^2}$	$\frac{I}{c}\times\frac{16800}{wL^2}$	$\frac{I}{c}\times\frac{13200}{wL^2}$	$\frac{I}{c}\times\frac{10800}{wL^2}$	$\frac{I}{c}\times\frac{13200}{wL^2}$
$L=125\sqrt{\frac{I}{wec}}$	$130\sqrt{\frac{I}{wec}}$	$115\sqrt{\frac{I}{wec}}$	$104\sqrt{\frac{I}{wec}}$	$115\sqrt{\frac{I}{wec}}$
For maximum safe deflection $\frac{L}{30}$.				
$I=\frac{wL^3e}{133350}$	$\frac{wL^3e}{151130}$	$\frac{wL^3e}{106680}$	$\frac{wL^3e}{88900}$	$\frac{wL^3e}{115570}$
$w=\frac{133350I}{L^3e}$	$\frac{151130I}{L^3e}$	$\frac{106680I}{L^3e}$	$\frac{88900I}{L^3e}$	$\frac{115570I}{L^3e}$
$e=\frac{133350I}{wL^3}$	$\frac{151130I}{wL^3}$	$\frac{106680I}{wL^3}$	$\frac{88900I}{wL^3}$	$\frac{115570I}{wL^3}$
$L=51.1\sqrt[3]{\frac{I}{we}}$	$53.3\sqrt[3]{\frac{I}{we}}$	$47.4\sqrt[3]{\frac{I}{we}}$	$44.6\sqrt[3]{\frac{I}{we}}$	$48.7\sqrt[3]{\frac{I}{we}}$
For directly computing I from $\frac{I}{c}$.				
$I=\frac{I}{c}\times0.117L$	$\frac{I}{c}\times0.111L$	$\frac{I}{c}\times0.113L$	$\frac{I}{c}\times0.122L$	$\frac{I}{c}\times0.114L$
For maximum safe fibre stress and deflection.				
$L=8.55c$	$8.98c$	$8.10c$	$8.27c$	$8.76c$
Actual maximum deflection.				
$\Delta=\frac{wL^4e}{3999750I}$	$\frac{wL^4e}{4533050I}$	$\frac{wL^4e}{3199800I}$	$\frac{wL^4e}{2666500I}$	$\frac{wL^4e}{3466450I}$

CASE 10B. FLOORING FIXED AT ENDS. LOAD UNIFORM

TABLE 18

General	Steel	Cast Iron	Fir, Wash.	Hemlock
For maximum fibre stress F				
$t=\sqrt{\frac{wL^2}{4000F}}$	....	....	$\frac{L\sqrt{w}}{52.8}$	$\frac{L\sqrt{w}}{42.4}$
$w=\frac{4000Ft^2}{L^2}$	....	....	$\frac{2800t^2}{L^2}$	$\frac{1800t^2}{L^2}$
$L=\sqrt{\frac{4000F}{w}}$	....	....	$\frac{52.8t}{\sqrt{w}}$	$\frac{42.4t}{\sqrt{w}}$
For maximum safe deflection $\frac{L}{30}$.				
$t=\sqrt[3]{\frac{wL^3}{14.82E}}$	....	....	$\frac{L\sqrt[3]{w}}{21.8}$	$\frac{L\sqrt[3]{w}}{18.9}$
$w=\frac{14.82Et^3}{L^3}$	....	....	$10374\frac{t^3}{L^3}$	$6669\frac{t^3}{L^3}$
$L=\sqrt[3]{\frac{14.82Et^3}{w}}$	....	....	$\frac{21.8t}{\sqrt[3]{w}}$	$\frac{18.9t}{\sqrt[3]{w}}$
For maximum safe fibre stress and deflection.				
$L=\frac{Et}{270F}$	....	....	$3.70t$	$3.70t$
Actual maximum deflection.				
$\Delta=\frac{wL^4}{444.4Et^3}$	....	....	$\frac{wL^4}{311080t^3}$	$\frac{wL^4}{199980t^3}$

CASE 10B. FLOORING FIXED AT ENDS. LOAD UNIFORM

TABLE 18

	Oak, Wh.	Pine, L.L.	Pine, S.L.	Pine, Wh.	Spruce
	For maximum safe fibre stress F.				
$t=$	$\frac{L\sqrt{w}}{50.9}$	$\frac{L\sqrt{w}}{52.8}$	$\frac{L\sqrt{w}}{46.9}$	$\frac{L\sqrt{w}}{42.4}$	$\frac{L\sqrt{w}}{46.9}$
$w=$	$\frac{2600t^2}{L^2}$	$\frac{2800t^2}{L^2}$	$\frac{2200t^2}{L^2}$	$\frac{1800t^2}{L^2}$	$\frac{2200t^2}{L^2}$
$L=$	$\frac{50.9t}{\sqrt{w}}$	$\frac{52.8t}{\sqrt{w}}$	$\frac{46.9t}{\sqrt{w}}$	$\frac{42.4t}{\sqrt{w}}$	$\frac{46.9t}{\sqrt{w}}$
	For maximum safe deflection $\frac{L}{30}$.				
$t=$	$\frac{L\sqrt[3]{w}}{22.3}$	$\frac{L\sqrt[3]{w}}{23.3}$	$\frac{L\sqrt[3]{w}}{20.7}$	$\frac{L\sqrt[3]{w}}{19.5}$	$\frac{L\sqrt[3]{w}}{21.3}$
$w=$	$11115\frac{t^3}{L^3}$	$12597\frac{t^3}{L^3}$	$8892\frac{t^3}{L^3}$	$7410\frac{t^3}{L^3}$	$9633\frac{t^3}{L^3}$
$L=$	$\frac{22.3t}{\sqrt[3]{w}}$	$\frac{23.3t}{\sqrt[3]{w}}$	$\frac{20.7t}{\sqrt[3]{w}}$	$\frac{19.5t}{\sqrt[3]{w}}$	$\frac{21.3t}{\sqrt[3]{w}}$
	For maximum safe fibre stress and deflection.				
$L=$	$4.27t$	$4.50t$	$4.04t$	$4.12t$	$4.38t$
	Actual maximum deflection.				
$\Delta=$	$\frac{wL^4}{333600t^3}$	$\frac{wL^4}{377740t^3}$	$\frac{wL^4}{266640t^3}$	$\frac{wL^4}{222200t^3}$	$\frac{wL^4}{288860t^3}$

SECTION MOMENT OF INERTIA FOR RECTANGULAR CROSS-SECTION. TABLE 20

Breadth of Section in Inches

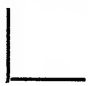
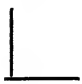
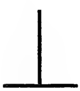
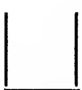
Depth in Inches.	1	$1\frac{5}{8}$	2	3	4	6	8	10	12	14	16	18	20	22	24
2	1	1	1	2	3	4	5	7	8	9	11	12	13	15	16
4	5	9	11	16	21	32	43	53	64	75	85	96	107	117	118
6	18	29	36	54	72	108	144	180	216	252	288	324	360	396	432
8	43	79	85	128	171	256	341	427	512	597	683	768	853	939	1024
10	83	135	167	250	333	500	667	833	1000	1167	1333	1500	1667	1833	2000
12	144	234	288	432	576	864	1152	1440	1728	2016	2304	2592	2880	3168	3456
14	229	371	457	686	915	1372	1829	2287	2744	3201	3659	4116	4573	5031	5488
16	341	554	683	1024	1365	2048	2731	3413	4096	4779	5461	6144	6827	7509	8192
18	486	790	972	1458	1944	2916	3888	4860	5832	6804	7776	8748	9720	10692	11664
20	667	1083	1333	2000	2667	4000	5333	6667	8000	9333	10667	12000	13333	14667	16000
22	887	1441	1774	2662	3549	5324	7099	8873	10648	12423	14197	15972	17757	19521	21296
24	1152	1872	2304	3456	4608	6912	9216	11520	13824	16128	18432	20736	23040	25344	27648

SECTION MODULUS $\frac{I}{}$ FOR RECTANGULAR CROSS-SECTION. TABLE 19

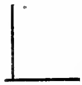
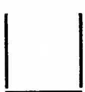
BREADTH OF SECTION IN INCHES

Depth in Inches.	1	$1\frac{5}{8}$	2	3	4	6	8	10	12	14	16	18	20	22	24
2	1	1	1	2	3	4	5	7	8	9	11	12	13	15	16
4	3	4	5	8	11	16	21	27	32	37	43	48	53	59	64
6	6	10	12	18	24	36	48	60	72	84	96	108	120	132	144
8	11	17	21	32	43	64	85	107	128	149	171	192	213	234	256
10	17	27	33	50	67	100	133	167	200	233	267	300	333	367	400
12	24	39	48	72	96	144	192	240	288	336	384	432	480	528	576
14	33	53	65	98	131	196	261	327	392	457	523	588	653	719	784
16	43	70	85	128	171	256	341	427	512	598	683	768	853	939	1024
18	54	88	108	162	216	324	432	540	648	756	864	972	1080	1188	1296
20	67	108	133	200	267	400	533	667	800	933	1067	1200	1333	1467	1600
22	81	131	161	242	323	484	645	807	968	1129	1291	1452	1614	1775	1936
24	96	156	192	288	384	576	768	960	1152	1344	1536	1728	1920	2112	2304

PROPERTIES OF CAST-IRON LINTELS. TABLE 21

Sect.	Dims.	$\frac{I}{c}$	⅝″ Metal.		$\frac{I}{c}$	¾″ Metal.		$\frac{I}{c}$	⅞″ Metal.	
			I	c		I	c		I	c
	6 × 6	14.0	24.2	1.73	15.8	28.2	1.78	17.4	31.9	1.83
	6 × 7	15.7	25.3	1.61	17.7	29.5	1.67	19.6	33.5	1.71
	6 × 8	17.3	26.3	1.52	19.6	30.8	1.57	21.7	34.9	1.61
	6 × 10	20.5	27.9	1.36	23.2	32.7	1.41	25.5	37.1	1.46
	6 × 12	23.5	29.2	1.24	26.5	34.2	1.29	28.9	38.8	1.34
	7 × 7	22.9	39.9	1.74	25.8	46.5	1.80	28.7	52.7	1.84
	7 × 8	25.2	41.2	1.64	28.5	48.4	1.70	31.6	54.9	1.74
	8 × 8	35.2	61.6	1.75	40.0	72.3	1.81	44.4	82.5	1.86
	8 × 10	...	...	....	36.6	74.6	2.04	40.6	85.2	2.10
	8 × 12	...	...	....	41.7	78.7	1.89	46.5	89.7	1.93
	9 × 8	...	...	....	36.5	97.1	2.66	40.9	110.8	2.71
	10 × 12	...	...	....	50.9	130.1	2.56	56.9	147.8	2.60
	12 × 12	...	...	....	74.4	246.4	3.28	85.7	284.2	3.32
	6 × 8	20.8	42.2	2.03	23.5	48.9	2.08	26.0	55.2	2.12
	6 × 10	24.4	45.3	1.87	27.7	53.1	1.92	30.6	60.0	1.96
	6 × 12	28.0	48.4	1.73	32.0	56.9	1.78	35.0	63.7	1.82
	6 × 14	...	...	....	35.4	59.1	1.67	39.2	67.0	1.71
	6 × 16	...	...	....	39.3	61.6	1.57	43.3	69.7	1.61
	6 × 18	...	...	....	42.5	63.3	1.49	47.1	72.1	1.53
	6 × 20	...	...	....	46.4	65.4	1.41	50.8	74.1	1.46
	8 × 12	...	...	....	49.5	127.0	2.57	55.4	144.6	2.61
	8 × 14	...	...	....	55.4	133.9	2.42	61.9	152.3	2.46
	8 × 16	...	...	....	61.3	139.7	2.28	68.3	159.0	2.33
	8 × 18	...	...	....	66.8	144.8	2.17	74.7	165.0	2.21
	8 × 20	...	...	....	72.6	149.4	2.06	80.8	170.4	2.11
	8 × 24	...	...	....	...	...	....	92.9	179.2	1.93
	8 × 28	...	...	....	...	...	....	104.1	186.5	1.79
	10 × 20	...	...	....	100.9	280.4	2.78	114.8	323.6	2.82
	10 × 24	...	...	....	...	...	....	131.6	342.0	2.60
	10 × 28	...	...	....	...	...	....	147.6	357.2	2.42
	12 × 20	...	...	....	130.7	465.3	3.56	148.2	533.7	3.60
	12 × 24	...	...	....	...	...	....	170.1	566.2	3.33
	12 × 28									

PROPERTIES OF CAST-IRON LINTELS. TABLE 22

Sect.	Dims.	$\frac{I}{c}$	1″ Metal.		$\frac{I}{c}$	1¼″ Metal.		$\frac{I}{c}$	1½″ Metal.	
			I	c		I	c		I	c
	6 × 6	19.0	35.4	1.87	21.4	42.0	1.96	23.4	47.7	2.04
	6 × 7	21.3	37.2	1.75	23.9	44.2	1.85	26.3	50.3	1.93
	6 × 8	23.5	38.7	1.65	26.2	45.9	1.75	28.8	52.6	1.83
	6 × 10	27.5	41.2	1.50	30.9	49.4	1.60	33.4	56.0	1.68
	6 × 12	31.2	43.1	1.38	34.7	51.3	1.48	37.4	58.7	1.57
	7 × 7	31.1	58.7	1.89	35.4	70.1	1.98	38.9	80.6	2.07
	7 × 8	34.6	61.8	1.79	38.5	72.7	1.89	42.8	84.2	1.97
	8 × 8	48.5	92.2	1.90	43.4	106.6	2.46	45.4	115.6	2.55
	8 × 10	44.3	95.2	2.15	51.0	114.2	2.24	56.7	131.9	2.33
	8 × 12	51.0	100.3	1.97	58.2	120.3	2.07	65.4	141.3	2.16
	9 × 8	45.5	124.3	2.75	52.6	149.6	2.85	59.0	172.7	2.93
	10 × 12	63.3	166.9	2.64	84.0	229.9	2.74	94.4	267.2	2.83
	12 × 12	94.6	318.5	3.37	111.6	387.0	3.47	123.4	437.7	3.55
	6 × 8	28.3	61.5	2.17	32.2	72.7	2.26	35.2	82.4	2.34
	6 × 10	33.3	66.6	2.00	37.7	78.9	2.09	41.4	89.8	2.17
	6 × 12	38.6	71.0	1.84	42.8	82.9	1.94	47.3	95.5	2.04
	6 × 14	42.5	74.4	1.75	47.6	87.1	1.83	52.5	100.8	1.92
	6 × 16	46.9	77.4	1.65	52.1	90.6	1.74	57.5	105.2	1.83
	6 × 18	51.0	80.0	1.57	56.9	93.8	1.65	62.2	108.9	1.75
	6 × 20	54.9	82.4	1.50	60.3	95.3	1.58	66.8	112.1	1.68
	8 × 12	60.8	161.5	2.66	70.2	192.9	2.75	78.5	221.8	2.83
	8 × 14	68.1	170.2	2.50	77.7	203.8	2.60	87.4	234.2	2.68
	8 × 16	75.1	177.9	2.37	85.2	209.4	2.46	96.6	245.1	2.54
	8 × 18	82.0	184.5	2.25	94.2	221.3	2.35	104.5	254.7	2.43
	8 × 20	88.6	190.4	2.15	102.0	228.5	2.24	113.1	263.6	2.33
	8 × 24	101.3	200.5	1.98	116.4	240.8	2.07	128.7	277.9	2.16
	8 × 28	113.4	208.7	1.84	129.9	250.7	1.93	144.1	289.6	2.02
	10 × 20	125.5	360.0	2.87	146.4	428.6	2.93	165.3	503.9	3.05
	10 × 24	144.1	380.1	2.64	166.3	455.4	2.74	188.5	533.6	2.83
	10 × 28	153.5	377.6	2.46	188.5	480.6	2.55	211.3	557.8	2.64
	12 × 20	165.2	600.8	3.64	194.3	728.3	3.75	222.2	849.9	3.83
	12 × 24	189.1	637.1	3.37	223.0	773.7	3.47	254.2	902.5	3.55
	12 × 28	212.8	667.7	3.14	250.5	811.4	3.24	284.7	948.0	3.33

PROPERTIES OF CAST-IRON LINTELS. TABLE 23

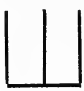
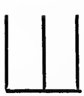
Sect.	Dims.	$\frac{I}{c}$	$\frac{5}{8}''$ Metal.		$\frac{I}{c}$	$\frac{3}{4}''$ Metal.		$\frac{I}{c}$	$\frac{7}{8}''$ Metal.	
			I	c		I	c		I	c
	8 × 16	59.2	155.5	2.63	68.4	183.9	2.69	75.9	207.7	2.73
	8 × 18	62.2	162.3	2.61	74.6	191.5	2.57	83.1	216.8	2.61
	8 × 20	....	.....	...	79.9	196.3	2.46	89.8	224.4	2.50
	8 × 24	....	.....	...	....	.....	...	105.0	238.3	2.27
	8 × 28									
	10 × 20	....	.....	...	111.9	366.9	3.28	126.2	420.4	3.33
	10 × 24	....	.....	...	....	.....	...	146.8	447.7	3.05
	10 × 28									
	12 × 20	....	.....	...	146.6	607.0	4.14	166.0	695.5	4.19
	12 × 24	....	.....	...	....	.....	...	185.5	729.4	3.87
	12 × 28									
			1″ Metal.			$1\frac{1}{4}''$ Metal.			$1\frac{1}{2}''$ Metal.	
	8 × 16	84.0	232.4	2.77	97.1	277.4	2.86	107.8	318.0	2.95
	8 × 18	91.5	242.3	2.65	105.2	289.4	2.75	117.5	332.4	2.83
	8 × 20	98.6	251.3	2.55	114.0	300.7	2.64	137.5	375.1	2.73
	8 × 24	112.7	267.1	2.37	130.0	319.8	2.46	144.5	367.1	2.54
	8 × 28	126.1	280.1	2.22	145.4	335.7	2.31	160.7	383.9	2.39
	10 × 20	139.8	471.3	3.37	163.6	567.4	3.47	184.9	655.9	3.55
	10 × 24	161.6	508.8	3.15	186.7	604.8	3.24	210.5	700.4	3.33
	10 × 28	178.4	527.8	2.96	209.2	637.9	3.05	235.7	737.6	3.13
	12 × 20	184.6	782.5	4.24	218.8	947.2	4.33	251.6	1110.8	4.42
	12 × 24	209.8	834.7	3.98	248.2	1011.0	4.07	283.5	1117.8	4.16
	12 × 28	234.9	880.0	3.75	278.0	1066.8	3.84	317.4	1246.5	3.93
			$1\frac{3}{4}''$ Metal.							
	12 × 28	314.0	1072.6	3.42						
	8 × 28	174.5	434.2	2.49						
	10 × 28	258.0	833.0	3.23						
	12 × 28	350.5	1408.0	4.02						

TABLE OF LOGARITHMS

TABLE OF LOGARITHMS. 0 TO 499

	0	1	2	3	4	5	6	7	8	9	Diff.
0	0000	0000	3010	4771	6021	6990	7782	8451	9031	9542	
1	0000	0414	0792	1139	1461	1761	2041	2304	2553	2788	
2	3010	3222	3424	3617	3802	3979	4150	4314	4472	4624	
3	4771	4914	5051	5185	5315	5441	5563	5682	5798	5911	
4	6021	6128	6232	6335	6435	6532	6628	6721	6812	6902	
5	6990	7076	7160	7243	7324	7404	7482	7559	7634	7709	
6	7782	7853	7924	7993	8062	8129	8195	8261	8325	8388	
7	8451	8513	8573	8633	8692	8751	8808	8865	8921	8976	
8	9031	9085	9138	9191	9243	9294	9345	9395	9445	9494	
9	9542	9590	9638	9685	9731	9777	9823	9868	9912	9956	
10	0000	0043	0086	0128	0170	0212	0253	0294	0334	0374	41.5
11	0414	0453	0492	0531	0569	0607	0645	0682	0719	0755	37.9
12	0792	0828	0864	0899	0934	0969	1004	1038	1072	1106	34.9
13	1139	1173	1206	1239	1271	1303	1335	1367	1399	1430	32.3
14	1461	1492	1523	1553	1584	1614	1644	1673	1703	1732	30.1
15	1761	1790	1818	1847	1875	1903	1931	1959	1987	2014	28.1
16	2041	2068	2095	2122	2148	2175	2201	2227	2253	2279	26.4
17	2304	2330	2355	2380	2405	2430	2455	2480	2504	2529	25.0
18	2553	2577	2601	2625	2648	2672	2695	2718	2742	2765	23.5
19	2788	2810	2833	2856	2878	2900	2923	2945	2967	2989	22.3
20	3010	3032	3054	3075	3096	3118	3139	3160	3181	3201	21.2
21	3222	3243	3263	3284	3304	3324	3345	3365	3385	3404	20.2
22	3424	3444	3464	3483	3502	3522	3541	3560	3579	3598	19.3
23	3617	3636	3655	3674	3692	3711	3729	3747	3766	3784	18.6
24	3802	3820	3838	3856	3874	3892	3909	3927	3945	3962	17.8
25	3979	3997	4014	4031	4048	4065	4082	4099	4116	4133	17.1
26	4150	4166	4183	4200	4216	4232	4249	4265	4281	4298	16.4
27	4314	4330	4346	4362	4378	4393	4409	4425	4440	4456	15.8
28	4472	4487	4502	4518	4533	4548	4564	4579	4594	4609	15.2
29	4624	4639	4654	4669	4683	4698	4713	4728	4742	4757	14.8
30	4771	4786	4800	4814	4829	4843	4857	4871	4886	4900	14.3
31	4914	4928	4942	4955	4969	4983	4997	5011	5024	5038	13.8
32	5051	5065	5079	5092	5105	5119	5132	5145	5159	5172	13.4
33	5185	5198	5211	5224	5237	5250	5263	5276	5289	5302	13.0
34	5315	5328	5340	5353	5366	5378	5391	5403	5416	5428	12.6
35	5441	5453	5465	5478	5490	5502	5514	5527	5539	5551	12.2
36	5563	5575	5587	5599	5611	5623	5635	5647	5658	5670	11.9
37	5682	5694	5705	5717	5729	5740	5752	5763	5775	5786	11.6
38	5798	5809	5821	5832	5843	5855	5866	5877	5888	5899	11.2
39	5911	5922	5933	5944	5955	5966	5977	5988	5999	6010	11.0
40	6021	6031	6042	6053	6064	6075	6085	6096	6107	6117	10.7
41	6128	6138	6149	6160	6170	6180	6191	6201	6212	6222	10.4
42	6232	6243	6253	6263	6274	6284	6294	6304	6314	6325	10.1
43	6335	6345	6355	6365	6375	6385	6395	6405	6415	6425	10.0
44	6435	6444	6454	6464	6474	6484	6493	6503	6513	6522	9.9
45	6532	6542	6551	6561	6571	6580	6590	6599	6609	6618	9.5
46	6628	6637	6646	6656	6665	6675	6684	6693	6702	6712	9.3
47	6721	6730	6739	6749	6758	6767	6776	6785	6794	6803	9.4
48	6812	6821	6830	6839	6848	6857	6866	6875	6884	6893	9.0
49	6902	6911	6920	6928	6937	6946	6955	6964	6972	6981	8.8

TABLE OF LOGARITHMS. **500 TO 999**

	0	1	2	3	4	5	6	7	8	9	Diff.
50	6990	6998	7007	7016	7024	7033	7042	7050	7059	7067	8.6
51	7076	7084	7093	7101	7110	7118	7126	7135	7143	7152	8.5
52	7160	7168	7177	7185	7193	7202	7210	7218	7226	7235	8.3
53	7243	7251	7259	7267	7275	7284	7292	7300	7308	7316	8.1
54	7324	7332	7340	7348	7356	7364	7372	7380	7388	7396	8.0
55	7404	7412	7419	7427	7435	7443	7451	7459	7466	7474	7.8
56	7482	7490	7497	7505	7513	7520	7528	7536	7543	7551	7.7
57	7559	7566	7574	7582	7589	7597	7604	7612	7619	7627	7.6
58	7634	7642	7649	7657	7664	7672	7679	7686	7694	7701	7.4
59	7709	7716	7723	7731	7738	7745	7752	7760	7767	7774	7.2
60	7782	7789	7796	7803	7810	7818	7825	7832	7839	7846	7.1
61	7853	7860	7868	7875	7882	7889	7896	7903	7910	7917	7.1
62	7924	7931	7938	7945	7952	7959	7966	7973	7980	7987	7.0
63	7993	8000	8007	8014	8021	8028	8035	8041	8048	8055	6.9
64	8062	8069	8075	8082	8089	8096	8102	8109	8116	8122	6.8
65	8129	8136	8142	8149	8156	8162	8169	8176	8182	8189	6.7
66	8195	8202	8209	8215	8222	8228	8235	8241	8248	8254	6.6
67	8261	8267	8274	8280	8287	8293	8299	8306	8312	8319	6.5
68	8325	8331	8338	8344	8351	8357	8363	8370	8376	8382	6.3
69	8388	8395	8401	8407	8414	8420	8426	8432	8439	8445	6.2
70	8451	8457	8463	8470	8476	8482	8488	8494	8500	8506	6.1
71	8513	8519	8525	8531	8537	8543	8549	8555	8561	8567	6.0
72	8573	8579	8585	8591	8597	8603	8609	8615	8621	8627	6.0
73	8633	8639	8645	8651	8657	8663	8669	8675	8681	8686	5.9
74	8692	8698	8704	8710	8716	8722	8727	8733	8739	8745	5.8
75	8751	8756	8762	8768	8774	8779	8785	8791	8797	8802	5.7
76	8808	8814	8820	8825	8831	8837	8842	8848	8854	8859	5.6
77	8865	8871	8876	8882	8887	8893	8899	8904	8910	8915	5.5
78	8921	8927	8932	8938	8943	8949	8954	8960	8965	8971	5.5
79	8976	8982	8987	8993	8998	9004	9009	9015	9020	9025	5.4
80	9031	9036	9042	9047	9053	9058	9063	9069	9074	9079	5.3
81	9085	9090	9096	9101	9106	9112	9117	9122	9128	9133	5.3
82	9138	9143	9149	9154	9159	9165	9170	9175	9180	9186	5.3
83	9191	9196	9201	9206	9212	9217	9222	9227	9232	9238	5.2
84	9243	9248	9253	9258	9263	9269	9274	9279	9284	9289	5.1
85	9294	9299	9304	9309	9315	9320	9325	9330	9335	9340	5.1
86	9345	9350	9355	9360	9365	9370	9375	9380	9385	9390	5.0
87	9395	9400	9405	9410	9415	9420	9425	9430	9435	9440	4.9
88	9445	9450	9455	9460	9465	9469	9474	9479	9484	9489	4.8
89	9494	9499	9504	9509	9513	9518	9523	9528	9533	9538	4.8
90	9542	9547	9552	9557	9562	9566	9571	9576	9581	9586	4.8
91	9590	9595	9600	9605	9609	9614	9619	9624	9628	9633	4.8
92	9638	9643	9647	9652	9657	9661	9666	9671	9675	9680	4.7
93	9685	9689	9694	9699	9703	9708	9713	9717	9722	9727	4.7
94	9731	9736	9741	9745	9750	9754	9759	9763	9768	9773	4.6
95	9777	9782	9786	9791	9795	9800	9805	9809	9814	9818	4.6
96	9823	9827	9832	9836	9841	9845	9850	9854	9859	9863	4.5
97	9868	9872	9877	9881	9886	9890	9894	9899	9903	9908	4.5
98	9912	9917	9921	9926	9930	9934	9939	9943	9948	9952	4.5
99	9956	9961	9965	9969	9974	9978	9983	9987	9991	9996	4.5

TABLE OF LOGARITHMS. **1000** TO **1499**

	0	1	2	3	4	5	6	7	8	9	Diff.
100	0000	0004	0009	0013	0017	0022	0026	0030	0035	0039	4.3
101	0043	0048	0052	0056	0060	0065	0069	0073	0077	0082	4.3
102	0086	0090	0095	0099	0103	0107	0111	0116	0120	0124	4.2
103	0128	0133	0137	0141	0145	0149	0154	0158	0162	0166	4.2
104	0170	0175	0179	0183	0187	0191	0195	0199	0204	0208	4.2
105	0212	0216	0220	0224	0228	0233	0237	0241	0245	0249	4.1
106	0253	0257	0261	0265	0269	0273	0278	0282	0286	0290	4.1
107	0294	0298	0302	0306	0310	0314	0318	0322	0326	0330	4.0
108	0334	0338	0342	0346	0350	0354	0358	0362	0366	0370	4.0
109	0374	0378	0382	0386	0390	0394	0398	0402	0406	0410	4.0
110	0414	0418	0422	0426	0430	0434	0438	0441	0445	0449	3.9
111	0453	0457	0461	0465	0469	0473	0477	0481	0484	0488	3.9
112	0492	0496	0500	0504	0508	0512	0515	0519	0523	0527	3.9
113	0531	0535	0538	0542	0546	0550	0554	0558	0561	0565	3.8
114	0569	0573	0577	0580	0584	0588	0592	0596	0599	0603	3.8
115	0607	0611	0615	0618	0622	0626	0630	0633	0637	0641	3.8
116	0645	0648	0652	0656	0660	0663	0667	0671	0674	0678	3.7
117	0682	0686	0689	0693	0697	0700	0704	0708	0711	0715	3.7
118	0719	0722	0726	0730	0734	0737	0741	0745	0748	0752	3.7
119	0755	0759	0763	0766	0770	0774	0777	0781	0785	0788	3.7
120	0792	0795	0799	0803	0806	0810	0813	0817	0821	0824	3.6
121	0828	0831	0835	0839	0842	0846	0849	0853	0856	0860	3.6
122	0864	0867	0871	0874	0878	0881	0885	0888	0892	0896	3.6
123	0899	0903	0906	0910	0913	0917	0920	0924	0927	0931	3.6
124	0934	0938	0941	0945	0948	0952	0955	0959	0962	0966	3.6
125	0969	0973	0976	0980	0983	0986	0990	0993	0997	1000	3.4
126	1004	1007	1011	1014	1017	1021	1024	1028	1031	1035	3.4
127	1038	1041	1045	1048	1052	1055	1059	1062	1065	1069	3.4
128	1072	1075	1079	1082	1086	1089	1092	1096	1099	1103	3.4
129	1106	1109	1113	1116	1119	1123	1126	1129	1133	1136	3.3
130	1139	1143	1146	1149	1153	1156	1159	1163	1166	1169	3.3
131	1173	1176	1179	1183	1186	1189	1193	1196	1199	1202	3.2
132	1206	1209	1212	1216	1219	1222	1225	1229	1232	1235	3.2
133	1239	1242	1245	1248	1252	1255	1258	1261	1265	1268	3.2
134	1271	1274	1278	1281	1284	1287	1290	1294	1297	1300	3.2
135	1303	1307	1310	1313	1316	1319	1323	1326	1329	1332	3.2
136	1335	1339	1342	1345	1348	1351	1355	1358	1361	1364	3.2
137	1367	1370	1374	1377	1380	1383	1386	1389	1392	1396	3.2
138	1399	1402	1405	1408	1411	1414	1418	1421	1424	1427	3.1
139	1430	1433	1436	1440	1443	1446	1449	1452	1455	1458	3.1
140	1461	1464	1467	1471	1474	1477	1480	1483	1486	1489	3.1
141	1492	1495	1498	1501	1504	1508	1511	1514	1517	1520	3.1
142	1523	1526	1529	1532	1535	1538	1541	1544	1547	1550	3.0
143	1553	1556	1559	1562	1565	1569	1572	1575	1578	1581	3.0
144	1584	1587	1590	1593	1596	1599	1602	1605	1608	1611	3.0
145	1614	1617	1620	1623	1626	1629	1632	1635	1638	1641	3.0
146	1644	1647	1649	1652	1655	1658	1661	1664	1667	1670	2.9
147	1673	1676	1679	1682	1685	1688	1691	1694	1697	1700	2.9
148	1703	1706	1708	1711	1714	1717	1720	1723	1726	1729	2.9
149	1732	1735	1738	1741	1744	1746	1749	1752	1755	1758	2.9

TABLE OF LOGARITHMS. 1500 TO 1999

	0	1	2	3	4	5	6	7	8	9	Diff.
150	1761	1764	1767	1770	1772	1775	1778	1781	1784	1787	2.9
151	1790	1793	1796	1798	1801	1804	1807	1810	1813	1816	2.9
152	1818	1821	1824	1827	1830	1833	1836	1838	1841	1844	2.9
153	1847	1850	1853	1855	1858	1861	1864	1867	1870	1872	2.8
154	1875	1878	1881	1884	1886	1889	1892	1895	1898	1901	2.8
155	1903	1906	1909	1912	1915	1917	1920	1923	1926	1928	2.8
156	1931	1934	1937	1940	1942	1945	1948	1951	1953	1956	2.8
157	1959	1962	1965	1967	1970	1973	1976	1978	1981	1984	2.8
158	1987	1989	1992	1995	1998	2000	2003	2006	2009	2011	2.7
159	2014	2017	2019	2022	2025	2028	2030	2033	2036	2038	2.7
160	2041	2044	2047	2049	2052	2055	2057	2060	2063	2066	2.7
161	2068	2071	2074	2076	2079	2082	2084	2087	2090	2092	2.7
162	2095	2098	2101	2103	2106	2109	2111	2114	2117	2119	2.7
163	2122	2125	2127	2130	2133	2135	2138	2140	2143	2146	2.7
164	2148	2151	2154	2156	2159	2162	2164	2167	2170	2172	2.7
165	2175	2177	2180	2183	2185	2188	2191	2193	2196	2198	2.6
166	2201	2204	2206	2209	2212	2214	2217	2219	2222	2225	2.6
167	2227	2230	2232	2235	2238	2240	2243	2245	2248	2251	2.6
168	2253	2256	2258	2261	2263	2266	2269	2271	2274	2276	2.6
169	2279	2281	2284	2287	2289	2292	2294	2297	2299	2302	2.6
170	2304	2307	2310	2312	2315	2317	2320	2322	2325	2327	2.6
171	2330	2333	2335	2338	2340	2343	2345	2348	2350	2353	2.6
172	2355	2358	2360	2363	2365	2368	2370	2373	2375	2378	2.6
173	2380	2383	2385	2388	2390	2393	2395	2398	2400	2403	2.6
174	2405	2408	2410	2413	2415	2418	2420	2423	2425	2428	2.6
175	2430	2433	2435	2438	2440	2443	2445	2448	2450	2453	2.6
176	2455	2458	2460	2463	2465	2467	2470	2472	2475	2477	2.4
177	2480	2482	2485	2487	2490	2492	2494	2497	2499	2502	2.4
178	2504	2507	2509	2512	2514	2516	2519	2521	2524	2526	2.4
179	2529	2531	2533	2536	2538	2541	2543	2545	2548	2550	2.3
180	2553	2555	2558	2560	2562	2565	2567	2570	2572	2574	2.3
181	2577	2579	2582	2584	2586	2589	2591	2594	2596	2598	2.3
182	2601	2603	2605	2608	2610	2613	2615	2617	2620	2622	2.3
183	2625	2627	2629	2632	2634	2636	2639	2641	2643	2646	2.3
184	2648	2651	2653	2655	2658	2660	2662	2665	2667	2669	2.3
185	2672	2674	2676	2679	2681	2683	2686	2688	2690	2693	2.3
186	2695	2697	2700	2702	2704	2707	2709	2711	2714	2716	2.3
187	2718	2721	2723	2725	2728	2730	2732	2735	2737	2739	2.3
188	2742	2744	2746	2749	2751	2753	2755	2758	2760	2762	2.2
189	2765	2767	2769	2772	2774	2776	2778	2781	2783	2785	2.2
190	2788	2790	2792	2794	2797	2799	2801	2804	2806	2808	2.2
191	2810	2813	2815	2817	2819	2822	2824	2826	2828	2831	2.2
192	2833	2835	2838	2840	2842	2844	2847	2849	2851	2853	2.2
193	2856	2858	2860	2862	2865	2867	2869	2871	2874	2876	2.2
194	2878	2880	2882	2885	2887	2889	2891	2894	2896	2898	2.2
195	2900	2903	2905	2907	2909	2911	2914	2916	2918	2920	2.2
196	2923	2925	2927	2929	2931	2934	2936	2938	2940	2942	2.1
197	2945	2947	2949	2951	2953	2956	2958	2960	2962	2964	2.1
198	2967	2969	2971	2973	2975	2978	2980	2982	2984	2986	2.1
199	2989	2991	2993	2995	2997	2999	3002	3004	3006	3008	2.1

150 m